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A
MANUAL
OF
COMPARATIVE ANATOMY.

A
MANUAL
OF
COMPARATIVE ANATOMY,

TRANSLATED FROM THE GERMAN

OF

J. F. BLUMENBACH,

WITH ADDITIONAL NOTES,

By WILLIAM LAWRENCE, Esq. F.R.S.

SURGEON TO ST. BARTHOLOMEW'S HOSPITAL, TO BRIDEWELL,
AND BETHLEM HOSPITALS,
&c. &c.

SECOND EDITION, REVISED AND AUGMENTED,

By WILLIAM COULSON,

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1827.

I

Blumenbach

J. M'Creery, Tooks Court,
Chancery-lane, London.

ADVERTISEMENT.

In submitting this work to the public, the Editor deems it right to state briefly in what respects the present edition of Mr. Lawrence's translation of Blumenbach differs from the original edition of 1807. The difference consists partly in the addition of new matter, and partly in a new, and, he trusts, improved arrangement both of the text of the author, and of the additional notes of the Translator.

With respect to the new disposition of the matter, the notes of Blumenbach have been incorporated, wherever it has been practicable to effect such an union, with the text; an arrangement which is sanctioned, in many instances, by the authority of the author himself in the later editions of his work; and which will be found, it is hoped, to contribute not less to the profit, than to the convenience of the student. Frequent annotations necessarily divert the attention of the reader from the chain of reasoning, or the detail of facts which the text may present to him; and there is the less reason for isolating the information contained in the notes of Blumenbach, as it is for the most part strictly relevant to the subject matter of the text. The additional notes of Mr. LAWRENCE, which, in the edition of 1807, were annexed *en masse* to the end of each chapter, have, in this edition, been printed in a distinct type at the end of each paragraph of the text which they are designed to illustrate.

Of the new matter, part has been introduced by the author in editions of this Manual, subsequent to that translated in 1807, and part has been annexed to, or incorporated with the notes of Mr. LAWRENCE by the present editor.

The works of the more recent physiologists and comparative anatomists, especially those of CUVIER, BLAINVILLE, RUDOLPHI, CARUS, MECKEL, TIEDEMANN, and the Lectures of Sir E. HOME, have been diligently examined, with a view of supplying such information as the lapse of twenty years had rendered necessary, in order to complete the plan of illustration adopted by the Translator. Many scarce and valuable monographs have also been consulted for that purpose. The information derived from these sources is in some instances sufficiently distinguished, by the dates of the works cited, from former additions to this Manual, and, where there is no such distinction apparent on the face of the additional matter, the Editor has not thought it necessary to point out what has been added to the commentaries of Mr.

Lawrence, preferring rather to place his own humble endeavours to increase the utility of the work under the shelter afforded to them by the name of the distinguished Translator.

To that eminent individual the Editor has now to make his public acknowledgments for the mark of friendship and confidence with which he has been honoured, in being intrusted with the superintendence of this publication. For the sake of the science, indeed, he regrets that the numerous professional avocations of Mr. Lawrence have prevented him from presenting the public with an improved edition of this, one of his earliest literary productions; but he trusts, that as far as diligence and zeal can supply the want of the Translator's superintending care, the confidence which has been reposed in him has not been entirely misplaced. Mr. Lawrence's translation of this work was produced at the outset of his professional life, at a time when a knowledge of the German language might be considered a rare acquisition in this country; and his illustrations of the text, even at this early period of his career, afforded an earnest of that reputation which he has since acquired by the splendour of his physiological researches. Blumenbach has himself borne ample testimony to the merits of his commentator; indeed it is as gratifying to remark the spirit of candour and cordial approbation with which the labours of our distinguished countryman are uniformly noticed by the continental writers, as it is humiliating to reflect on the spirit of envy and malignity by which they have been assailed at home. Envy and malignity, however, have done their worst; it may be said rather that they have had the effect of establishing the fame of Mr. LAWRENCE, and of placing, beyond all competition, his claims to the highest rank in his profession.

The Editor cannot conclude these observations without expressing his acknowledgments to Mr. Clift, the conservator of the Hunterian Museum, for the great facilities he has afforded him in the prosecution of inquiries connected with this publication. The value of the Hunterian Museum, with a view to any practical advantage that can be derived from it in physiological or pathological investigations, is indeed greatly diminished by the want of a digested catalogue of its contents. This want will, it is to be hoped, be speedily supplied; in the mean time nothing is better calculated to diminish the inconveniences resulting from it, than the urbanity, and the readiness to afford information, which are displayed on all occasions by the present conservator.

WILLIAM COULSON.

59, *Aldersgate Street*,
Oct. 1, 1827.

THE AUTHOR'S PREFACE

TO

THE FOURTH EDITION.

I was first led, both by inclination and by the nature of my professional pursuits, to devote the greater portion of my time to the study of physiology, or the foundation of medical science, as it has been termed by Zimmermann, and to natural history, or the *materia prima philosophiæ*, as it has been called by Bacon. I soon became convinced, and experience has confirmed my conviction, that Haller was right when he said of comparative anatomy, that it had thrown more light upon physiology than even the dissection of the human subject; an opinion which has been further sanctioned by the authority of Leibnitz, who has declared comparative anatomy to be the soul of that branch of knowledge which is dedicated to the history of the animal kingdom. If I may venture to believe that I have not laboured in vain in these two departments of science, the success of my efforts is to be attributed to the collateral assistance which I have derived from comparative anatomy. As I may at least claim the merit of having been the first to deliver lectures annually on this subject, in Germany, and of having by these means excited a taste for the science, and a zeal to contribute to its advancement; so I trust that this edition of my Manual, the first work of the kind which has ever appeared on comparative anatomy, as applied to the whole animal kingdom, will further facilitate the study, and render it more universally useful. I have the more reason to think that my readers will approve the plan of this work, as it is, in fact, the same which I have pursued in my elementary treatises on physiology and natural history; and which, from the various advantages it combines, has been found best calculated to afford facilities to students.

To give effect to such a plan it was necessary to make a judicious selection from the vast mass of materials which have been accumulated by the labours of comparative anatomists. This I have endeavoured to accomplish, while at the same time I have kept in view the application of the science to physiology and natural history, and have occasionally interspersed a few remarks illustrative of these branches of knowledge. It is evident that a minute description of the muscles, vessels, nerves, &c., of the various classes of animals, could not be comprised within the limits which I have prescribed to myself. Comparative Osteology, however, deserves a more detailed examination, for the skeletons of red-blooded animals are not only intimately connected with the rest of their anatomical structure, but also with their form, economy, and peculiar habits.

To domestic animals, and to such as the sports of the field bring most frequently under our notice, I have paid particular attention; partly, because such animals are most easily procured for dissection, and partly on account of the great interest which is likely to be taken in a correct knowledge of their structure. With regard to foreign animals, I have uniformly adverted to their most striking peculiarities.

I have carefully cited my authorities for such facts as I have not myself had an opportunity of verifying; availing myself, in such cases, partly of the best engravings which have been published, and partly of the best monographs, and papers which have appeared on the subject of comparative anatomy in periodical collections; so that I have scarcely omitted to notice a single author who has contributed any thing of importance, and the notes to this

Manual furnish a complete synopsis of the literature of the science.

I have devoted a large portion of the work to the classes of warm-blooded animals, as those in which readers, whose time will not admit of extended investigation, will take the greatest interest. I have not, however, neglected the classes of cold-blooded animals, and the two last classes of the Linnæan system, having generally explained the comparative anatomy of the invertebrated animals, by an example or two taken from each class.

To such authorities as the large systematic works of BLAINVILLE, CARUS, CUVIER, GEOFFROY, MECKEL, RUDOLPHI, TIEDEMANN, and TREVIRANUS, I now, to avoid frequent repetition, refer once for all. The same observation applies to the engravings given by some of these writers, and especially by CUVIER and CARUS, as well as to the masterly monographs of BOJANUS, CUVIER, HOME, SPIX, TIEDEMANN, &c., and to the copious *additional notes* with which the celebrated LAWRENCE has enriched his translation of this Manual.*

I shall scarcely be expected to offer any apology for not having translated many well known technical Latin terms, the translation of which would, in fact, have rendered the things signified less intelligible; nor is it, I trust, necessary for me to enlarge on the numerous additions and improvements by which the utility of the work has been increased in this edition.

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* Notwithstanding this observation, the author has very frequently quoted Mr. Lawrence's notes; but in this edition, where the notes so cited immediately follow the text, references of this kind are of course omitted.—ED.

J. F. Blumenbach.

Gottingen,
March 31, 1824.

INTRODUCTION.*

ANATOMICAL structure is the natural foundation on which a systematic arrangement of the different classes and species which compose the animal kingdom may be established. ARISTOTLE has adopted to a certain extent this basis of classification; but it is evident that no great advances could be made by the ancients in a branch of knowledge, which presupposes an intimate acquaintance with the structure and organization of animals. No attempt at classification before the time of LINNÆUS has any pretensions to the name of a system affording accurate criteria for distinguishing the different classes of animals. The classification of Linnæus, which is adopted with some modifications by BLUMENBACH in the following work, is founded on the observation of differences of structure in the organs of circulation in such animals as possess a cardiac system.

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* This introduction is substantially the same as that given by Mr. Lawrence in the original edition of this work.

Mammalia, viviparous .	Heart furnished with two ventricles, two auricles; blood warm and red.
Birds, oviparous . . .	
Amphibia, respiring by lungs	Heart furnished with one ventricle and one auricle; blood cold and red.
Fishes, breathing by gills . . . . . - .	
Insects, furnished with antennæ	Sanies cold and colourless.
Vermes, furnished with tentacula	

Animals may be divided into two great families; the first family possessing vertebræ and red blood; the second without vertebræ, and most of them with white blood. The former have always an internal articulated skeleton, of which the chief connecting part is the vertebral column. The anterior part of this column supports the head; the canal which passes from one end of it to the other incloses the common fasciculus of the nerves; its posterior extremity is most frequently prolonged, in order to form the tail, and its sides are articulated with the ribs, which are seldom wanting. None of this family of animals has more than four limbs, some of them have two only, and others have none.

The brain is inclosed in a particular osseous cavity of the head, called the cranium. All the nerves of the spine contribute filaments to form a nervous cord, which has its origin in the nerves of the cranium, and is distributed to the greater part of the viscera.

The senses are always five in number. There are always two eyes, moveable at pleasure. The ear has always at least three semicircular canals. The sense of smell is always confined to particular cavities in the fore part of the head.

The circulation is always performed by one fleshy ventricle at least; and where the ventricles are two in number, they are always close together, forming a single mass. The absorbent vessels are distinct from the sanguiferous veins.

The two jaws are always placed horizontally, and open from above downwards. The intestinal canal is continued without interruption from the mouth to the anus, which is always placed behind the pelvis, that is, behind the circle of bones which affords a fixed point for the posterior extremities. The intestines are enveloped within a membranous sac, termed peritonæum. There is always a liver and a pancreas, which pour their secretions into the cavity of the intestines; and there is always a spleen, within which part of the blood undergoes some preparatory change before it is sent to the liver.

There are always two kidneys for the secretion of urine, placed on the two sides of the spine, and without the peritonæum. The testicles also are always two in number. There are always two bodies called atrabiliary capsules, placed over the kidneys; the use of them is unknown.

Animals with vertebræ are subdivided into two classes, one of which is warm-blooded, and the other cold-blooded.

Warm-blooded vertebrated animals have always two ventricles and a double circulation. They respire by means of lungs, and cannot exist without respiration. The brain almost always fills the cavity of the cranium. The eyes are covered with eyelids. The tympanum of the ear is sunk within the cranium; the different parts of the labyrinth are completely inclosed within bone; and besides the semicircular canals, the labyrinth contains the cochlea, with two *scalæ*, resembling the shell of the snail. The nostrils always communicate with the throat, and afford a passage for the air in respiration. The trunk is furnished with ribs, and almost all the species of this branch of animals have four limbs.

Cold-blooded vertebrated animals resemble one another more by their negative than their positive characters. Many of them are destitute of ribs; some of them are totally destitute of limbs. The brain never fills the whole cavity of the cranium.

The eyes seldom have moveable eyelids. The tympanum of the ear, when present, is always close to the surface of the head; it is often absent, as are likewise the ossicula auditus; the cochlea is always wanting. The different parts of the ear are not firmly attached to the cranium; they are often loosely connected to it in the same cavity as the brain.

Each of these two branches is subdivided into two classes.

The two classes of warm-blooded animals are the *Mammalia* and *Birds*.

The *Mammalia* are viviparous, and suckle their young with milk secreted by the mammæ. The females have consequently always the cavity termed uterus with two cornua, and the males have always a penis.

The head is supported on the first vertebra by two eminences. The vertebræ of the neck are never less than six, nor more than nine. The brain has a more complicated structure than in other animals, and contains many parts which are not to be found in the other classes, such as the corpus callosum, fornix, pons, &c.

The eyes have two eyelids only. The ear contains four small bones, articulated together, and has a spiral cochlea. The tongue is quite soft and fleshy. The skin is covered entirely with hairs, in the greatest number, and in all it is covered partially.

The lungs fill the cavity of the chest, which is separated from the abdomen by a fleshy diaphragm.

There is one larynx only, situated at the basis of the tongue, and completely covered by the epiglottis, when the animal swallows.

The lower jaw only is moveable; both jaws are covered with lips.

The biliary and pancreatic ducts are inserted into the intestinal canal at the same place. The lacteal vessels convey a white milky chyle, and pass through a number of conglobate glands, situated at the mesentery. A membrane, called omentum, suspended from the stomach and adjacent viscera, covers the fore part of the intestines. The spleen is always upon the left side, between the stomach, ribs, and diaphragm.

BLUMENBACH establishes the following orders in this class:*

Ordo I. BIMANUS. Two handed.
Genus. *Homo.*

II. QUADRUMANA, four-handed animals: having a separate thumb capable of being opposed to the other fingers, both in their upper and lower extremities, teeth like those of man, except that the *cuspidati* are generally longer.

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* Vid. GORE's translation of BLUMENBACH's *Natural History*, p. 32.

1. *Simiæ*, apes, monkeys, baboons.
2. *Lemur*, macauco.

III. CHIROPTERA.

The fingers of the fore feet, the thumb excepted, are, in these animals, longer than the whole body; and between them is stretched a thin membrane for flying. Hence they are as little capable of walking on the ground as apes, with their hands, or sloths, with their hooked claws, which are calculated for climbing.

1. *Vespertilio,* bat, calugo, &c.

IV. DIGITATA.

Mammifera, with separate toes on all four feet. This order contains the greatest number of genera and species, and is therefore conveniently divided, according to the differences of the teeth, into three families, *glires*, *feræ*, and *bruta.*

(A) GLIRES.

With two chisel-shaped incisor teeth in each jaw, for the purpose of gnawing without canine teeth.

1. *Sciurus*, squirrel.

2. *Glis*, dormouse (*Myoxus, Linn.*)
3. *Mus*, mouse and rat.
4. *Marmota*, marmot.
5. *Savia*, guinea-pig.
6. *Lepus*, hare and rabbit.
7. *Jaculus*, jerboa.
8. *Hystrix*, porcupine.

(B) FERÆ.

With pointed or angular front teeth, and mostly with only a single canine tooth on each side, which is generally, however, of remarkable size and strength. The carnivorous animals, properly so called, and some other genera with teeth of the same kind, compose this family.

1. *Erinaceus*, hedgehog.
2. *Sorex*, shrew.
3. *Talpa*, mole.
4. *Didelphis marsupialis*, opossum.
5. *Viverræ*, weasels, ferret, polecat, civet.
6. *Mustela*, stunk, stoat, &c.
7. *Ursus*, bear.
8. *Canis*, dog, wolf, jackall, fox, hyæna.
9. *Felis*, cat, lion, tiger, leopard, lynx, panther, &c.

The three first genera belong to the insectivora of CUVIER; their feet are short, and their power of motion weak. They have no cœcum, and walking they rest the whole of the foot on the ground. They live principally on insects, whence their name is derived. The fourth genus belongs to the marsupialia of CUVIER; the animals of this class have a pouch in the abdomen which contains the mammæ, as well as the young in their early state. The remaining genera, with the exception of the bear, belong to the digitigrada of CUVIER.

(C) BRUTA.

Without teeth, or at least without front teeth.

1. *Bradypus*, sloth.
2. *Myrmecophaga*, ant-eater.
3. *Manis*, scaly ant-eater.
4. *Dasypus* or *Tatu*, armadillo.

This order forms the edentata of CUVIER, the tongue is long, slender, and projectile, for seizing the insects on which the animals live. The armadillo, manis, ant-eater, and ornithorhynchus, or duck-billed animal, belong to this order.

V. SOLIDUNGULA (Solipeda, Cuv.).

A single toe on each foot, with an undivided hoof. Large intestines, and particularly an enormous cœcum. Incisors in both jaws.

1. *Equus*, horse or ass.

VI. BISULCA (Pecora).

These are the ruminantia of CUVIER, their hoof is divided. No incisors in the upper jaw. Stomach consisting of four cavities. Rumination of the food. Long intestines.

1. *Camelus*, camel, dromedary, lama.
2. *Capra*, sheep, goat.
3. *Antilope*, antelope, chamois.
4. *Bos*, ox, buffalo.
5. *Giraffa*, giraffe, or camelopard.
6. *Cervus*, elk, deer kind.
7. *Moschus*, musk.

VII. MULTUNGULA (Belluæ).

Animals of an unshapely form, and a tough and thick hide; whence they have been called by CUVIER *pachydermata* (from παχυς thick, and δερμα skin). They have more than two toes; incisors in both jaws, and in some cases enormous tusks.

1. *Sus*, pig kind, pecari, babiroussa.
2. *Tapir*.
3. *Elephas*.
4. *Rhinoceros*.
5. *Hippopotamus*.

VIII. PALMATA.

Mammifera with webbed feet, the genera being divided (as in the order Digitata) according to the forms of the teeth into three families:

(A) *Glires.* (B) *Feræ.* (C) *Bruta.*

(A) GLIRES.

With chisel-shaped gnawing teeth.

Castor, beaver.

(B) FERÆ.

With the teeth of carnivorous animals.

Phoca, seal.

(C) BRUTA.

Without teeth, or at least without front teeth.

Ornithorhynchus, duck-billed animal.
Trichechus, walrus.

The last genus of the order, together with the phoca, (seal) constitutes the amphibia of CUVIER. These animals have short members adapted for swimming.

IX. CETACEA.

Whales living entirely in the sea, and formed like fishes; breathe by an opening at the top of the head, called the *blowing-hole,* through which they throw out the water, which enters their mouth with the food.

Smooth skin covering a thick layer of oily fat. No external ear. A complicated stomach. Multilobular kidneys; larynx of a pyramidal shape, opening towards the blowing hole. Testes within the abdomen. Mammæ at the sides of the vulva. Bones of the anterior extremity concealed and united by the skin, so as to form a kind of fin.

1. *Monodon*, narwhale, sea-unicorn.
2. *Balæna*, proper whales.
3. *Physeter*, macrocephalus, white whale.
4. *Delphinus*, dolphin, porpoise.

Cuvier distributes the class *mammalia* into three grand divisions:

1. Those which have claws or nails, (*mammifères à ongles*) including the following orders: bimana, quadrumana, chiroptera, plantigrada, carnivora, pedimana, rodentia, edentata, tardigrada.

2. Those which have hoofs (*mammif. à ongles*) including the pachydermata, ruminantia, and solipeda.

3. Those which have extremities adapted for swimming (*mammif. à pieds en nageoire*). Amphibia and cetacea.

BIRDS.

Birds are oviparous. They have only one ovarium and one oviduct, in which they differ from other oviparous animals. The head is supported on the first vertebræ of the neck by a single eminence. The vertebræ of the neck are very numerous, and the sternum very large. The anterior extremities are used for flying, and the posterior for walking.

The eyes have three eyelids. There is no external ear; the tympanum contains only one bone, and the cochlea is a cone slightly curved. The tongue has a bone internally. The body is covered with feathers. The lungs are attached to the ribs. The air passes through the lungs in its way to the air-bags, which are dispersed throughout the body. There is no diaphragm. The trachea has a larynx at each end, and the upper one has no epiglottis. The upper mouth consists of a horny bill without lips, teeth, or gums, and both mandibles are moveable.

The pancreas and liver send out several excretory ducts, which enter the intestines at different places. The chyle is transparent, and there are no mesenteric glands nor omentum. The spleen is in the centre of the mesentery. The ureters terminate in a cavity called the cloaca, which also affords an exit to the solid excrement and to the eggs. There is no urinary bladder.

This class cannot be distributed into orders so clearly distinguished by anatomical characters as the preceding one. Blumenbach divides them into two leading divisions.

(A) LAND BIRDS.

Order I. ACCIPITRES. Birds of prey, almost all with short strong feet, large sharp claws, and a strong hooked beak, which for the most part terminates above in two short cutting points, and is commonly covered at the root with a fleshy membrane. A membranous stomach, and short cœca.

1. *Vultur*, vultures.
2. *Falco*, falcon, eagle, hawk, kite.
3. *Strix*, owl.
4. *Lanius*, shrike or butcher-bird.

II. LEVIROSTRES. Light-billed birds, having a large hollow bill.

1. *Psittacus*, parrot kind.
2. *Ramphastos*, toucan.
3. *Buceros*, rhinoceros bird.

III. PICI. The birds of this order have short feet, and commonly a straight bill.

1. *Picus*, woodpecker.
2. *Jynx*, wryneck.
3. *Sitta*, nuthatch.
4. *Alcedo*, kingsfisher.
5. *Merops*, bee-eater.
6. *Upupa*, hoopoe.

7. *Certhio*, creeper.
8. *Trochilus*, humming birds, &c. &c.

IV. Coraces. The birds of this order have short feet with a strong bill, convex on the upper part, and of moderate size.

1. *Buphagar*, ox-pecker.
2. *Crotophaga*, razor-billed blackbird.
3. *Corvus*, crow, raven, jackdaw, magpie, jay, &c.
4. *Coracias*, roller.
5. *Gracula*, minor grakle.
6. *Paradisea*, birds of paradise.
7. *Cuculus*, cuckoo.
8. *Oriolus*, oriole.

V. Passeres. Small singing birds, with short and slender feet, and conical sharp-pointed bills of various size and form.

1. *Alauda*, lark.
2. *Sturnus*, starling.
3. *Turdus*, thrush, blackbird.
4. *Ampelis*, chatterer.
5. *Loxia*, cross-billed tribe.
6. *Emberizo*, bunting.
7. *Fringilla*, finches, canary-bird, linnet, sparrow.
8. *Musicapa*, fly-catcher.

9. *Motacilla*, nightingale, redbreast, wren.
10. *Pipra*, manakin.
11. *Parus*, titmouse.
12. *Hirundo*, swallow, martins, &c.
13. *Caprimulgus*, goatsucker, &c.

VI. Gallinæ. Gallinaceous birds, mostly domesticated, have short legs with a convex bill, which is covered with a fleshy membrane at its base, and of which the upper half overlaps the lower on each side. They possess a large crop.

1. *Columba*, pigeons.
2. *Tetrao*, grouse, quail, partridge.
3. *Numida*, guinea-fowl.
4. *Phasianus*, cock pheasant.
5. *Crax*, curesso.
6. *Meleagris*, turkey.
7. *Pavo*, peacock.
8. *Otis*, bustard.

VII. Struthiones. Struthious birds. The largest of the class; possess extremely small wings, and are therefore incapable of flight; but run very swiftly.

1. *Struthio*, ostrich, cassowary.
2. *Didus*, dodo.

(B) Aquatic Birds.

Order I. Grallæ. These birds have cylindrical bills of various lengths; long stilt-like legs; long neck, and short tail. They mostly live in marshes, and feed on amphibia.

1. *Phœnicopterus*, flamingo.
2. *Platalæa*, spoonbill.
3. *Palamedea*, horned screamer.
4. *Ardea*, crane, stork, heron, bittern.
5. *Tantalus*, ibis, &c.
6. *Scolopax*, woodcock, snipe, curlew.
7. *Tringa*, lapwing, ruffs and reeves.
8. *Charadrius*, plover.
9. *Hamatopus*, sea-pie.
10. *Fulica*, water-hen, coot.
11. *Parra*, spur-winged water-hen.
12. *Rallus*, rail.
13. *Psophia*, trumpeter.

II. Anseres. Swimming birds; web-footed; the upper mandible mostly ends in a little hook, and, together with the lower, is in most instances plentifully supplied with nerves.

1. *Rhincops*, sea-crow.
2. *Sterna*, noddy, silver bird.
3. *Colymbus*, diver.

4. *Larus,* gull.
5. *Plotus,* darter.
6. *Phæton,* tropic bird.
7. *Procellaria,* petrel.
8. *Diomedea,* albatross.
9. *Pelecanus,* pelican, cormorant.
10. *Anas,* swan, duck, goose.
11. *Mergus,* goosander.
12. *Alca,* auk, puffin.
13. *Aptenodytes,* penguin.

The two classes of *cold-blooded vertebral animals* are the

AMPHIBIA AND FISHES.

The animals of the former class differ from one another in many very essential particulars, and have not so many characters in common as the other classes. Some of the reptiles walk, some fly, some swim, many can only creep. The organs of the senses, and particularly the ear, differ almost as much as the organs of motion; none of the reptiles, however, have a cochlea. The skin is either naked or covered with scales. The brain is always very small. The lungs are in the same cavity with the other viscera; there are no air-bags beyond the lungs, but the cells of these organs are very large. There is but one larynx, and no epiglottis. Both the jaws are moveable. There are neither mesenteric glands, nor omentum. The spleen is in the centre of the mesentery. The female has always two ovaria and two oviducts. There is a bladder.

The class of reptiles, in the arrangement of Cuvier, corresponds to the orders of reptiles pedati, and serpentes apodes, belonging to the class of amphibia in the *Systema Naturæ* of Linnæus.

Order I. Reptilia, having four feet, (*quadrupeda ovipara*) the toes of which are, according to their mode of life, either separate, (*pedes digitati*) connected by membranes, (*palmati*) or confounded with one another in the form of a fin (*pinnati*).

1. ***Testudo,*** tortoise, turtle.
2. ***Rana***, frog, toad.
3. ***Draco***, dragon.
4. ***Lacerta***, lizards, crocodiles, chameleon, newt, salamander, iguana, &c.

II. Serpentia. No external organs of motion; body of an elongated form, covered with scales, plates, or rings. Their slender, and for the most part cloven tongue serves them for tasting. Many are provided with an active venom, contained in little bags on the front of the upper jaw, secreted by particular glands, and conveyed into the wound made in biting by means of isolated teeth, which are tubular, with a longitudinal opening at the top. They are oviparous, but the egg is sometimes hatched in the oviduct. Both jaws moveable.

1. *Crotalus*, rattle-snake.
2. *Boa.* Immense serpents of India and Africa.
3. *Coluber*, viper.
4. *Anguis*, blind-worm.
5. *Amphisbæna.*
6. *Cæcilia.*

Fishes respire by means of organs in the shape of combs, placed at the two sides of the neck, between which they force water to pass. They have, consequently, neither trachea, larynx, nor voice. The body is formed for swimming. Besides the four fins, which correspond to the limbs, they have vertical ones upon the back, under the tail, and at its extremity; but they are sometimes wanting.

The nostrils are not employed in respiration. The ear is quite hid within the cranium. The skin is naked, or covered with scales. The tongue is osseous. Both jaws are moveable. There are often cœca in place of the pancreas. There is a bladder and two ovaria.*

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* The class of *Fishes* include the *Fishes* and the *Amphibia Nantes* of LINNÆUS.

The animals destitute of vertebræ have less in common, and form a less regular series than the vertebrated animals. But, when they have hard parts, these are generally placed on the outside of the body, at least when articulated; and the nervous system has not its middle part inclosed within a canal of bone, but loosely situated in the same cavity with the other viscera.

The brain is the only part of the nervous system which is placed above the alimentary canal. It sends out two branches, which encircle the œsophagus like a necklace, and which afterwards unite and form the common fasciculus of the nerves.

None of the animals without vertebræ respire by cellular lungs, and none of them have a voice. Their jaws are placed in all kinds of directions, and many of them have only organs of suction. None of them have kidneys, or secrete urine. Those among them which have articulated members have always six at least.

(A) CARTILAGINOUS FISHES.

Order I. CHONDROPTERYGII; have no branchial operculum, and, in most, the mouth is placed on the under side of the head.

1. *Petromyzon*, lamprey.
2. *Gastrobranchus*, hag-fish.
3. *Raia*, ray, skate, torpedo, stingray.

4. *Squalus*, shark, saw-fish.
5. *Lophius*, sea-devil, frog-fish.
6. *Balistes*, file-fish.
7. *Chimæra*, sea-ape.

II. Branchiostegi, with opercula to the gills.

1. *Accipenser*, sturgeon, beluga.
2. *Ostracion*, trunk-fish.
3. *Tetrodon*, globe-fish.
4. *Diodon*, porcupine-fish.
5. *Cyclopterus*, lumpsucker.
6. *Centriscus*, snipe-fish.
7. *Syngnathus*, pipe-fish.
8. *Pegasus*, sea-dragon.

(B) Bony Fishes, divided according to the situation of their fins.

Order I. Apodes, without ventral fins.

1. *Muræna*, eel-kind.
2. *Gymnotus*, electrical eel.
3. *Trichiurus*.
4. *Anarrhichus*, sea-wolf.
5. *Ammodites*, launce.
6. *Ophidium*.
7. *Stromateus*.
8. *Xiphias*, sword-fish.
9. *Leptocephalus*.

II. JUGULARES. Ventral fins in front of the thoracic.

1. *Callionymus*, dragonet.
2. *Uranoscopus*, star-gazer.
3. *Trachinus*, sting-fish.
4. *Gadus*, haddock, cod, whiting, ling.
5. *Blennius*, eel-pout.

III. THORACICI. Ventral fins directly under the thoracic.

1. *Cepola*, ribbon-fish.
2. *Echeneis*, sucking fish.
3. *Coryphæna*, dorado.
4. *Gobius*, gudgeon.
5. *Cottus*, pogge.
6. *Scorpæna*.
7. *Zeus*, dory.
8. *Pleuronectes*, flounder, plaice, dab, halibut, sole, turbot.
9. *Chætodon*.
10. *Sparus*, gilthead, sea-bream.
11. *Labrus*, rainbow-fish.
12. *Sciænæ*.
13. *Perca*, perch.
14. *Gasterosteus*, stickleback.
15. *Scomber*, mackerel, bonito, tunny.
16. *Mullus*, mullet.
17. *Trigla*, flying-fish.

IV. Abdominales. Ventral fins behind the thoracic; chiefly inhabit fresh water.

1. *Cobitis*, loach.
2. *Silurus.*
3. *Loncaria*, harness-fish.
4. *Salmo*, salmon, trout, smelt.
5. *Fistularia.*
6. *Esox*, pike.
7. *Polypterus.*
8. *Elops.*
9. *Argentina.*
10. *Atherina.*
11. *Mugil.*
12. *Exocœtus.*
13. *Polynemus.*
14. *Clupea*, herring, sprat, shad.
15. *Cyprinus*, carp, tench, gold-fish, minnow, &c. &c.

The *invertebral animals* were distributed by Linnæus into two classes, *insects* and *worms* (*vermes*). The anatomical structure of these animals was very imperfectly known when the Swedish naturalist first promulgated his arrangement. But the labours of subsequent zoologists, and particularly those of Cuvier, have succeeded in establishing such striking and important differences in their formation, that a subdivision of the Linnæan classes becomes indispensably necessary. The insects of LINNÆUS are divided into *crustacea* and *insecta;* and the *vermes* of the same author form three classes, viz. *mollusca, vermes,* and *zoophyta.*

The *Insects* form the third class.

In their perfect state they have, like the crustacea, articulated limbs and antennæ. Most of them have also membranous wings, which enable them to fly. All these last pass through several metamorphoses, in one of which they are quite destitute of the power of motion. All of them have a nervous system similar to that of the crustacea; but insects have neither heart nor blood-vessels, and respire by tracheæ. Not only the liver, but all the secreting organs are wanting, and their place is supplied by long vessels, which float loosely in the abdomen. The form of the intestinal canal is often very different in the same individual, in its three different states.*

The animals which resemble the larvæ of insects, and have, like them, the medullary cord knotted, may be placed in the same class with insects, though they undergo no metamorphosis; but there are some of that number which have distinct sanguiferous vessels, and which must be arranged in a separate class, intermediate between the mollusca, crustacea, and insects. To this class belong *earth-worms* and *leeches*.

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* The class of *Insects* corresponds to the same class in the Systema Naturæ, with the exception of the two genera separated from it, in order to form the class of crustacea.

Order I. Coleoptera. Having a hollow horny case, under which the wings are folded.

1. *Scarabæus,* beetles.
2. *Lucanus,* stag-beetle.
3. *Dermestes.*
4. *Ptinus.*
5. *Histur.*
6. *Gyrinus.*
7. *Byrrhus,*
8. *Silpha,* carrion beetle.
9. *Cassida,* tortoise beetle.
10. *Coccinella,* ladybird.
11. *Chrysomela.*
12. *Hispa.*
13. *Bruchus,* seed-beetle.
14. *Curculio,* weevil.
15. *Attelabus,* nut-beetle.
16. *Cerambyx.*
17. *Leptura.*
18. *Necydalis.*
19. *Lampyris,* glow-worm.
20. *Cantharis.*
21. *Elater,* skipper.

22. *Cicindela.*
23. *Buprestis.*
24. *Dyticus*, water-beetle.
25. *Carabus.*
26. *Tenebrio*, meal-worm beetle.
27. *Meloe*, Spanish fly.
28. *Mordella.*
29. *Staphylinus.*
30. *Forficula*, earwig.

II. HEMIPTERA. Four wings, either stretched straight out, or resting across each other. Some are provided with jaws, others with a proboscis, bent towards the abdomen.

1. *Blatta*, cockroach.
2. *Mantis.*
3. *Gryllus*, locust, grasshopper.
4. *Fulgora*, lantern-fly.
5. *Cicada.*
6. *Notonecta.*
7. *Nepa*, water scorpion.
8. *Cimex*, bug.
9. *Aphis*, plant louse.
10. *Chermes.*
11. *Coccus.*
12. *Thrips.*

III. Lepidoptera. Soft hairy body, and four expanded wings, covered with coloured scales.

1. *Papilio*, butterfly.
2. *Sphinx*, hawk moth.
3. *Phalæna*, moth.

IV. Neuroptera. Four reticulated wings, glittering with colours of every kind.

1. *Libellula*, dragon-fly.
2. *Ephemera*, day-fly.
3. *Phryganea*, water-moth.
4. *Hemerobius*.
5. *Myrmeleon*, ant-lion.

V. Hymenoptera. Generally possessing a sting, and having four membranous wings.

1. *Cynips*.
2. *Tenthredo*.
3. *Sirex*.
4. *Ichneumon*.
5. *Sphex*.
6. *Chrysis*, golden fly.
7. *Vespa*, wasp, hornet.
8. *Apis*, bee.
9. *Formica*, ant.
10. *Termes*, white ant.

VI. Diptera. Two-winged insects, having two small balances placed on the thorax behind the wings, and generally covered with a little scale.

1. *Œstrus*, gad-fly.
2. *Tipula*, crane fly.
3. *Musca*, common fly.
4. *Tabanus*, gnat.
5. *Culex*, gnat, mosquito.
6. *Empis*.
7. *Conops*.
8. *Asilus*, hornet fly.
9. *Hippobosca*, horse-leech.

VII. Aptera. No wings.

1. *Lepisma*, sugar-mite.
2. *Produra*, springtail.
3. *Pediculus*, louse.
4. *Pulex*, flea.
5. *Acarus*, tick, mite.
6. *Hydrachna*.
7. *Phalangium*, shepherd.
8. *Aranea*, spider.
9. *Scorpio*, scorpion.
10. *Cancer*, crab.
11. *Monoculus*, horse-shoe fisch.
12. *Oniscus*.
13. *Scolopendra*.
14. *Julus*, centipede.

The VERMES may be divided into two orders; the *intestinal*, which inhabit the bodies of other animals; and the external.

The former are not of such a complicated organization as the latter; so that they are sometimes arranged among the zoophytes. The external worms have a nervous chord possessing ganglia, an elongated body composed of rings; and having no distinct head. There are no members. Circulating vessels, but no heart. No nerves have been discovered in the intestinal worms.

The class of *worms* comprehends some of the genera arranged by LINNÆUS among the *vermes intestina*, such as the *lumbricus, gordius, thrudo;* some of the genera placed by the same naturalist among the *vermes mollusca*, such as the *aphrodita, nereis, terebella*, and lastly some genera included in his order of *vermes testacea*, such as the *serpula dentalium.*

ORDER I. INTESTINA.

1. *Gordius*, hair-worm.
2. *Ascaris*, thread-worm, round-worm.
3. *Trichocephalus.*
4. *Echinorhynchus.*
5. *Lumbricus*, earth-worm.
6. *Fasciola*, fluke.
7. *Tænia*, tape-worm.
8. *Hydatis*, hydatid.

9. *Sipunculus.*
10. *Hirudo,* leech.

The class of *mollusca* comprehends the greater part of the animals which Linnæus has arranged in the two orders of *mollusca* and *testacea,* in the class of *vermes;* such as the *sepia, limax, ascidia, helix, ostrea, patella, pholas, teredo,* &c.

The body of the mollusca is fleshy, soft, and without articulated members, though sometimes containing hard parts internally, and sometimes covered completely by hard shells. They have arterial and venous vessels, within which the blood undergoes a true circulation.

They respire by branchiæ. The brain is a distinct mass, from which the nerves and medulla oblongata proceed. There are ganglia in different parts of the body.

The internal senses vary as to their number. Some of the mollusca have the organs of sight and hearing quite distinct, while others seem to be confined to the senses of touch and taste. Many of them can masticate their food; others have the power of swallowing only.

They have a very large liver, which affords a great quantity of bile. The organs of generation vary extremely.

II. MOLLUSCA.

1. *Limax*, slug.
2. *Aplysia.*
3. *Doris.*
4. *Glaucus.*
5. *Aphrodita,* sea-mouse.
6. *Amphitrite.*
7. *Nereis.*
8. *Nais.*
9. *Ascidia.*
10. *Actinia.*
11. *Tethys.*
12. *Holothuria.*
13. *Thalia.*
14. *Terebella.*
15. *Lernæa.*
16. *Scyllæa.*
17. *Clio.*
18. *Sepia,* cuttle-fish.
19. *Medusa,* sea-blubber.

III. TESTACEA. These animals very much resemble the worms of the preceding order.

1. *Chiton.*
2. *Lepas,* acorn-shell.
3. *Pholas,* pierce-stone.
4. *Mya,* muscle.
5. *Solen,* razor-shell.

6. *Tellina.*
7. *Cardium,* cockle.
8. *Mactra.*
9. *Donax.*
10. *Venus.*
11. *Spondylus.*
12. *Chama.*
13. *Arca,* ark.
14. *Ostrea,* oyster.
15. *Anomia.*
16. *Mytilus,* muscle.
17. *Pinna,* sea-wing.
18. *Argonauta,* paper-sailor.
19. *Nautilus.*
20. *Conus.*
21. *Cypræa.*
22. *Bulla,* dipper.
23. *Voluta,* rhomb-shell.
24. *Buccinum,* whelk.
25. *Strombus,* screw.
26. *Murex,* rock-shell.
27. *Trochus,* top-shell.
28. *Turbo,* whirl-wreath.
29. *Helix,* snail.
30. *Merita.*
31. *Haliotis,* sea-ear.
32. *Patella,* limpet.
33. *Dentalium,* tooth-shell.

34. *Serpula*, worm-shell.
35. *Teredo.*

IV. CRUSTACEA.

The body is covered with a hard crust in separate pieces. There are articulated limbs, which are often very numerous. The nervous system consists of a long, knotted cord, from the ganglia of which proceed all the nerves.

The eyes are compound, hard, moveable. The ears are very imperfect. For the sense of touch, the *crustacea* have antennæ and palpi, like insects. They have a heart, arterial and venous vessels, and branchiæ for respiration. The jaws are transverse, strong, and numerous. The stomach has teeth within. The numerous cœca afford a brown liquor, which seems to be in the place of bile. The penis is double, and there are two ovaria.*

1. *Echinus*, sea-hedgehog.
2. *Asterias*, sea-stars.
3. *Encrinus.*

V. CORALLIA.

They inhabit certain immovable dwellings which, in most cases, are of a stony consistence, and are called *corals.*

---

* The *crustacea* include the genus *cancer* and the genus *monoculus* of LINNÆUS.

1. *Tubipora.*
2. *Madrepora.*
3. *Millepora.*
4. *Cellepora.*
5. *Isis.*
6. *Gorgonia.*
7. *Alcyonium,* animal hydra.
8. *Spongia.*
9. *Flustra.*
10. *Tubularia.*
11. *Corallina.*
12. *Sertularia.*
13. *Cellularia.*

VI. ZOOPHYTA.

The class of *Zoophytes* correspond to the *Zoophyta* and *lythopyta* of LINNÆUS, but also include some of the vermes mollusca, such as the *echinus, asterias, holothuria, actinia, medusa,* together with the genus *sipunculus* from the vermes intestina.

1. *Pennatula.*
2. *Hydra.*
3. *Brachionus,* blossom-polype.
4. *Vorticella.*
5. *Furcularia,* wheel-animal.
6. *Vibrio.*
7. *Volvox.*
8. *Chaos.*

Outline of Cuvier's Classification of Animals; with Examples of Species belonging to each Division.

I. VERTEBRATA.

1. MAMMALIA.

Bimana, man.
Quadrumana, monkey, ape, lemur.
Cheiroptera, bat, colugo.
Insectivora, hedgehog, shrew, mole.
Plantigrada, bear, badger, glutton.
Digitigrada, dog, lion, cat, martin, weasel, otter.
Amphibia, seal, walrus.
Marsupialia, opossum, kangaroo.
Rodentia, beaver, rat, squirrel, porcupine, horse.
Edentata, sloth, armadillo, ant-eater, pangolin.
Pachydermata, elephant, hog, rhinoceros, tapir, horse.
Ruminantia, camel, musk, deer, giraffe, antelope, goat, sheep, ox.
Cetacea, dolphin, whale.

2. AVES.

Accipitres, vulture, eagle, owl.
Passeres, thrush, swallow, lark, crow, sparrow, wren.
Scansores, woodpecker, cuckoo, toucan, parrot.
Gallinæ, peacock, pheasant, grouse, pigeon.
Grallæ, plover, stork, snipe, ibis, flamingo.
Palmipedes, auk, grebe, gull, pelican, swan, duck.

3. REPTILIA.

Chelonia, tortoise, turtle.
Sauria, crocodile, lizard, chamelion.
Ophidia, serpents, boa, viper.
Batrachia, frog, salamander, proteus, siren.

4. PISCES.

Chondropterygii, lamprey, shark, ray, sturgeon.
Plectognathi, sun-fish, trunk-fish.
Lophobranchi, pipe-fish, pegasus.
Malacopterygii, salmon, herring, pike, carp, silurus, cod, sole, remora, eel.
Acanthopterygii, perch, mackerel, sword-fish.

II. MOLLUSCA.

Cephalopoda, sepia, nautilus.
Pteropoda, clio, hyalæa.
Gasteropoda, slug, snail, limpet.
Acephala, oyster, muscle, ascidia, pyrosoma.
Brachiopoda, lingula, terebratula.
Cirrhopoda, barnacle.

III. ARTICULATA.

1. ANNELIDES, or VERMES.

Tubicolæ, serpula, sabella.
Dorsibranchiæ, nereis, aphrodite.
Abranchiæ, earth-worm, leech.

2. CRUSTACEA.

Decapoda, crab, lobster, prawn.
Stomapoda, squill.
Amphipoda, gammarus.
Isopoda, asellus.
Branchiopoda, monoculus.

3. ARACHNIDA.

Pulmonalia, spider, scorpion.
Trachealia, phalangium, mite.

4. INSECTA.

Aptera, centipede, podura.
Coleoptera, beetle, glow-worm.
Orthoptera, grasshopper, locust.
Hemiptera, fire-fly, aphis.
Neuroptera, dragon-fly, ephemera.
Hymenoptera, bee, wasp, ant.
Lepidoptera, butterfly, moth.
Rhipiptera, xenos, stylops.
Diptera, gnat, house-fly.

IV. ZOOPHYTA.

Echinodermata, starfish, echinus.
Entozoa, fluke, tænia, hydatid.
Acalephæ, actinia, medusa.
Polypi, hydra, coralline, pennatula, sponge.
Infusoria, brachionus, vibrio, proteus, monas.

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COMPARATIVE OSTEOLOGY.

COMPARATIVE OSTEOLOGY.

CHAPTER I.

ON THE BONES OF ANIMALS IN GENERAL.

§ 1. RED-BLOODED animals only possess a true *skeleton*;* to which their bones are connected, and on which the general form,† as well as the greater or less flexibility of the body depends. There are a few exceptions to the general rule, that *all the bones of an animal enter into the formation of its skeleton*, viz. the bone of the tongue, commonly called *os hyoides;* the bone of the penis in several mammalia; the bony ring in the sclerotica of birds; the *clavicular bones* of some mammalia; to which instances may be added the whole anterior extremity in such mammalia as possess no clavicles; and the abdominal fins of fishes, which correspond to the posterior extremities of other animals.

§ 2. The ordinary white‡ colour of the bones has several gradations, which are sometimes observable in the different parts of the same bone; as in the grinding teeth of the elephant; a section of which, or of the tooth of any other herbivorous animal, as the horse, ox, &c. shews that its substance contains parts differing considerably in appearance. Besides the processes of enamel, which are intermingled throughout with the bone, there are two kinds of osseous structure of different colours. In some few genera the whole bony structure is of a different colour;* thus, in the garpike, (*esox belone*) the bones are green; and in some varieties of the common fowl they approach to a black colour.†

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* Parts of a really bony structure are found in a few insects and worms, viz. in the stomach of the lobster, and other species of the genus *cancer;* in the mouth of the sea-hedgehog (*echinus*), &c. These parts at least resemble true bones more than that body, which is commonly called *cuttlefish bone.*

† See Galen's remarks on the resemblance between the ape and the human subject, in the 1st book of his *Chef-d'œuvre de Anatomicis Administrationibus*, tom. iv. p. 26, Chartier's edition.

‡ The red tint, which the bones of animals receive in consequence of madder being mixed with the food, is observed by Ant. Misaud, in his *Centuriæ Memorabilium seu Arcanorum omnis generis*, p. 161. Cologne, 1572, 12mo. It is remarkable that this well known experiment meets with very imperfect success in cold-blooded animals.

§ 3. The structure of the bones is subject to still greater variations; which occur in the different bones of the same skeleton, as well as in the whole skeleton of particular classes and orders. Instances may be observed in the dry and brittle texture of the air bones of birds; in the long fibres which appear on splitting the bones of the larger amphibia and fishes; in the peculiar tenacity and solidity of individual parts in some cartilaginous fishes.

Ossification does not go on with equal rapidity in all animals, nor in all the bones of the same animal. Thus, the ossification of the internal ear of man, and other mammalia, is completed before any other parts; and the bone formed at this early period surpasses all others in density, and in the proportional quantity of phosphate of lime which it contains. In the *cetacea*, particularly the *balæna* and *physeter*, (the black and white whales) this part acquires a density and hardness equal to those of marble. Its section presents a homogeneous appearance, without the least vestige of fibres, cellular texture, or vessels.

Bones are slow in their formation in proportion to the remoteness of the period at which the growth of the animal is finished. The skeleton remains constantly in a cartilaginous state in some animals; such as the *shark, skate, sturgeon*, and all those fishes which, from this circumstance, have been denominated cartilaginous, or *chondropterygii.* Although the bones of other fishes, of reptiles, and serpents, acquire a greater hardness, they constantly remain more flexible, and retain a larger proportion of gelatine in their structure, than those of warm-blooded animals.

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* This has, however, been asserted without foundation of some animals: thus, Nicholls, in his *Compend. Anat.* p. 7, says, that the *amedabad finch (fringilla amandava)* has yellow bones; and others have stated the same circumstance respecting the *golden pheasant (phasianus pictus)*. I have dissected both these animals, and found the assertions to be incorrect.

† Abulfazel, the vizier of Akber the Great, has remarked this of the fowls at Indore, and Neermul in Berar, in his classical work, *Ayeen Akbery*, vol. ii. p. 72; and Niebuhr has stated it of those at Persepolis. *Travels*, vol. ii. p. 12.

The bony texture of quadrupeds is not so fine and delicate as that of man: it is particularly loose and coarse in the *cetacea*, where the distinction of the fibres is very manifest, even on the external surface. In the jaw and the ribs particularly, the fibres may be loosened by maceration, and become very obvious.

The bones of birds consist of a thin, firm, elastic substance, formed of layers apparently fastened on each other. They are almost universally hollow; but their cavities, which never contain marrow, are filled with air. This organization unites the advantages of lightness and strength.

The bones of reptiles and fishes have a very homogeneous appearance, the earthy matter and the gelatine appearing to be uniformly mingled: this is more strikingly marked, as we approach to the cartilaginous fishes, where the gelatine predominates, and conceals the earth.

Several animals have no medullary cavities even in their long bones. This is the case with the *cetacea,* the *seal,* and *turtle.*

The *horn* of the stag is a real bone, as appears both from its texture, and its component elements. Its outer part is hard, compact, and fibrous; the internal substance is reticulated, but very firm; and possesses neither cavities nor marrow. It is liable to precisely the same diseases as other bones; thus, we sometimes find exostoses formed upon its surface by the extravasation of its calcareous matter, while in other instances, from a deficiency of this component part, it is rendered light and porous.

The shells of the testaceous animals are formed of a calcareous substance, which is sometimes laminated; sometimes as hard and dense as marble. This substance is mingled, as in other bones, with a gelatinous matter, from which it may be separated by means of acids. The earth is not disposed in fibres, or laminæ, as in other bones; but is uniformly expanded through the animal substance.

The layers of the shell are formed successively, as the animal increases in size. The exterior or smallest are formed first: others are successively deposited on the inner surface of these; each new layer extending beyond the margin of the former one, so that the shell, by every addition, increases in thickness and circumference. Are these new layers formed by vessels existing in the shell itself, or are they produced by exudation from the surface of the animal? Reaumur broke the shell of snails, and found that no reproduction took place, when he covered the exposed part of the animal's body; while the injury was quickly repaired, when no artificial obstacle impeded the effusion of fluids from the surface. This experiment seems to prove that the shell is formed by deposition from the body.

of the animal; but there is an argument equally strong in favour of the existence of vessels in the shell itself. Between the two last formed layers of the convex shell of the oyster, a considerable cavity is found, filled with a fetid and bitter fluid, and communicating by a particular opening with the internal parts of the body.—This must be destroyed and reproduced whenever a new lamina is added; and we cannot understand how such processes can be effected without arterial and absorbing vessels.

Crustaceous animals (crab, lobster, &c.) have a skeleton which surrounds and contains their soft parts, and which serves at the same time the purposes of a skin. When it has attained its perfect consistence, it grows no more; but as the soft parts still increase, the shell separates, and is detached, being succeeded by a larger one. This new covering is partly formed before the other separates; it is at first soft, sensible, and vascular; but it speedily acquires a hard consistence by the increased deposition of calcareous matter.

Some of the *mollusca* have hard parts in the interior of their body. The common cuttlefish (*sepia officinalis*) has a white, firm, and calcareous mass, of an oval form, and slightly convex on its two surfaces, commonly known by the name of the *cuttlefish-bone*, contained in the substance of its body. It has no connexion with any soft part, whence it appears completely as a foreign body: no vessel or nerve can be perceived to enter it; nor does it receive the attachment of any tendon. In the calmar (*sepia loligo*) this body resembles horn in its appearance; it is transparent, hard, and brittle. Its form resembles that of a leaf, except that it is larger; and sometimes that of a sword-blade. This structure must grow like shells, by the simple addition of successive layers.

§ 4. Excepting the crown of the teeth, bones are universally covered with periosteum; and for the most part they contain marrow* internally; which varies much in consistence, being fluid in whales.

§ 5. Bones are formed by the ossification of original cartilages; the teeth being again for the most part excepted. Ossification commences earlier, and proceeds more rapidly in viviparous, than in oviparous animals. This fact appears at least from comparing the incubated bird with the fœtus of mammalia. It is well known, that the incubation of the chick occupies twenty-one days. The commencement of ossification is not perceptible before the beginning of the ninth day; which corresponds with the seventeenth week of human pregnancy. In the human embryo the first points of ossification may be discerned in the seventh or eighth week after conception, certainly not in the third or fourth week, as some anatomists have supposed. These facts shew how little confidence can be placed in that remark of Haller's, which concludes his otherwise masterly observations on the formation of the bones in the incubated chick: *Quæ de pullorum ossibus demonstravimus, ea etiam de aliis animantium classibus vera erunt, et de ipso demum homine:* "What I have proved as to the bones of the chick, will hold good with respect to those of other classes of animals, and of man." Of the mammalia, it is to be observed, that many points in the formation of the bones are completed sooner in quadrupeds than in man. An example occurs in the closure of the fontanelles. I have found these openings of considerable size in young fœtuses of the *feræ* and *pecora*, but could hardly discern any trace of them at the time of birth; nothing at least which could be compared to their magnitude in a human fœtus of nine months. When we compare the pelvis, and the whole mechanism of parturition in the woman, with those of the female quadruped, the cause of this difference appears. We then discover why the yielding and overlapping of the large bones of the cranium, which is chiefly effected by the fontanelles, is only required to facilitate the birth of the human fœtus.

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* The erroneous opinion which Aristotle held, of the want of marrow in the bones of the lion, does not require an express refutation. On that subject, as well as on some other mistaken assertions, see R. Hener, *Apolog. pro* Vesalio *adversus* Sylvium. Venet. 1555, 8vo. p. 27.

Professor Florman, of Sund, however, denies altogether the appearance of the fontanelles in the skulls of young animals, according to *Weber's and Mohr's Natur-histor. Reise durch einen Theil Schwedens,* p. 35. But I have found them in many of the digitata, as for instance in the new born lepus, of very considerable size.

As chemical analysis has discovered some interesting differences in the constituent ingredients of the hard parts of various animals, it seems right to give a short account of them in the present place.

The bones and teeth of red-blooded animals consist chiefly of phosphate of lime, deposited in the interstices of an animal substance; which, when freed from the earthy matter by the immersion of the bone in an acid, approaches in its consistence to cartilage. This is completely dissolved by boiling in a close vessel, and is thereby proved to consist of gelatine. A small quantity of carbonate of lime is mixed with the phosphate; and hence effervescence arises when a bone or tooth is subjected to the action of acids.

The horn of the stag is bone, containing a large proportion of gelatine.

The bones of fishes contain phosphate of lime; but the animal substance exists in very large proportion, particularly in those which are called cartilaginous, where it completely obscures the earthy matter.

Carbonate and phosphate of lime, deposited on a cartilaginous basis, which retains the form of the part, after the earthy matter has been separated, constitute the external covering of the crustaceous animals, (crab, lobster, &c.). The carbonate is in greatest quantity.

Carbonate of lime, with a small quantity of phosphate, forms the earthy principle of the shell of the echinus.

The shells of the testacea are entirely composed of carbonate of lime, united to a gelatinous substance. When immersed in acid, a rapid effervescence ensues. Some of them, which are very hard in their texture, and have an enamelled surface, contain so little animal matter, that they are completely dissolved by acids, like the enamel of the teeth. But others, which consist of what is called mother of pearl, and are formed by successive strata, (e. g. the oyster, muscle, &c.) contain a much larger proportion. When these have been macerated in acid, a gelatinous substance remains, consisting of several layers of membrane, arranged stratum super stratum.

It appears therefore, that *phosphate of lime* is the peculiar earth of *bone*, and *carbonate* that of *shell;* although no bone has been hitherto discovered without a small admixture of the latter ingredient. Hence, that singular production from the body of the cuttle-fish is improperly called bone; as it consists, like shells, of various membranes, hardened by carbonate of lime, without any phosphate. See "*Experiments and Observations on Shell and Bone*," by C. Hatchett, Esq. *Philos. Trans.* 1799.

The same excellent chemist has also found, that the *zoophytes* consist of carbonate of lime joined in different instances to various proportions of animal substance. *Philos. Trans.* 1800, Part II.

CHAPTER II.

ON THE SKELETON OF MAMMALIA.

§ 6. The form of the different mammalia, particularly the four-footed ones,* varies considerably; and their skeletons must be marked by corresponding differences. Yet these varieties may be included, at least for the greatest part, under the following peculiarities; which serve to distinguish their skeletons from those of birds.

The skeletons of mammalia possess;	Those of birds are distinguished by;
1. A skull with genuine sutures (at least with very few exceptions; as perhaps the *elephant,* and the duck-billed animal,† *ornithorhynchus*).	1. A skull which has not real sutures.‡
2. Jaws furnished with teeth; except the *ant-eaters,* the *manis,* the duck-billed animal,§ the *balæna* (whale).	2. A bill without teeth.

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* Compare this chapter with Goëthe's ingenious osteological view of the four-footed animals, in the 1st vol. of his *Morphologie,* p. 165; and the instructive plates of the skeletons of quadrupeds, of which I have given a sketch in my work on the bones, to which may be also added what has most recently appeared on this subject in *Cuvier's Ossemens Fossiles,* and the Treatise of Dr. Pander and Professor D'Alton.

† This is the case, at least, with my specimen: the cranium, destitute of sutures, strikingly resembles that of a bird in this respect.

‡ This is meant to apply to adult birds; for young individuals have at least separate cranial bones, if they are not connected by real denticulated sutures. The bones of the head in birds are joined either by the squamous kind of suture; or by the mere apposition of their margins, which species of union is termed *harmonia;* but they are soon consolidated into a single piece.

§ The duck-billed animal has, however, according to Cuvier, two teeth situated at the bottom of the mouth, without roots, with flat crowns, and composed like those of the oricteropus, of small vertical tubes.

3. An immoveable upper jaw.	3. A moveable upper jaw: There are some exceptions, viz. the *rhinoceros bird.*
4. An *os intermaxillare.* (For the probable exceptions, see § 15.)	4. No *os intermaxillare.*
5. Two occipital condyles.	5. A single occipital condyle.
6. Seven cervical vertebræ; except the *three-toed sloth,* and some *cetacea.*	6. More than seven cervical vertebræ.
7. Moveable dorsal vertebræ.	7. Dorsal vertebræ little moveable, and for the most part motionless.
8. A pelvis closed in front; except the *ant-eaters;* which have it open; and the *cetacea,* which have none.	8. A pelvis open anteriorly. Except the *ostrich.*
9. True clavicles in a few genera only.	9. Clavicles constantly, and almost as universally the *fork-like bone.**

§ 7. We shall first describe the cranium† of mammalia; since its structure most materially influences the whole animal economy, from serving as a receptacle for the brain, most of the organs of sense, and those of mastication ‡

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* The rudiments of this bone are to be found in the cassowary and ostrich, see § 57.

† Compare the numerous plates of the skulls of many animals, of both warm-blooded classes in the Atlas to Gall's and Spurzheim's *Anat. du Syst. Nerveux,* and in *Spix's Cephalogenesis,* and the useful observations on the skull and other parts of the skeleton in many quadrupeds in Dr. Neegaard's *Beyträgen zur vergleichenden Anatomie,* &c. Gottingen, 1807-8, p. 91.

‡ J. P. Frank was perhaps the first to notice the analogy between the vertebræ and skull, in the 11th volume of his *Delectus Opusculorum Medicor.* 1792, p. 8. *In ea semper opinione versatus sum quamcunque spinalis columnæ vertebram pro parvo, eodemque transverso, cranio esse considerandum:* "I have always been of opinion that every vertebra of the spinal column is to be regarded as a small transverse cranium;" and again, *extrema et ex omnibus maxime conspicua, nobilissimaque vertebra, quam calva-*

§ 8. The well known division of the bones of the head into those of the cranium and of the face, is convenient for pointing out the remarkable proportions of relative magnitude in the two divisions.* Compare, for instance, the skull of the *kangaroo* (*didelphis gigantea*) with that of the *opossum*, (*did. marsupialis*) or the skull of the *dolphin* (*delphinus delphis*) with that of the white whale (*physeter macrocephalus*).

§ 9. The number of proper bones of the cranium is, on the whole, the same as in the human subject. The os frontis, however, in most of the horned animals, is composed of two equal portions; in many of these the two parietal bones are consolidated into one, and in others they are united to the occiput. Some of the digitata have a peculiar flat bone situated transversely between the parietal and occipital bones.†

§ 10. As the forehead of man is peculiarly distinguished by the beauty of its convex superficies, so is that of many of the quadrumana, as the larger animals of the monkey tribe, *papio mormon*, &c. by the large flat triangular surface into which it is compressed, and the sides of which converge from the *processus malares* at the external angles of the orbits, obliquely backwards, towards the *crista occipitalis*.‡

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riam appellamus: "the last and most conspicuous and moveable of all the vertebræ, is that called the calvaria, or skull-cap." These views are further developed by Oken in his treatise *Uber die Bedeutung der Schädelknocken*, Jena, 1807; and Ulrich *De Sensu ac Significatione Ossium Capitis, speciatim de Capite Testudinis.* Berlin, 1816.

* A profile view answers as well for this purpose as a view taken vertically. I have explained the use of the latter, (which I call *norma verticalis*) in comparing the national forms of human crania, in the 3rd edition of my work, *De Generis humani Varietate Nativa*, p. 203, and in the 4th, *Decas. Crani. divers. Gent.* p. 12. See also Wolt, H. Crull, *de Cranio, ejusque ad Faciem ratione*, Gronig. 1810, Spix; and Mr. Lawrence's excellent *Lectures on Physiology*, Lond. 1819.

† See Merrem's anatomy of the domestic mouse, in his *Miscellaneous Observations on Natural History*, and Meyer's *Prodromus Anat. Murium*, who calls it *os transversum:* particularly Gotthelf Fischer's treatise *De Osse Epactali, seu Gothiano Palmigradorum, Mosquæ*, 1811. Some excellent observations on the developement of this bone, and on that of the *os occipitis* in many of the mammalia are to be found in Meckel's *Handbuch der Pathologische Anatomie*, vol. i. p. 326.

‡ In the horrid-looking skull, which I possess in my collection, of a person thirty years of age, and idiotic from birth, and which I have described in the *Commentatio de Anomalis et vitiosis quibusdam Nisus Formativi Aberrationibus*, Gott,

The sphenoid bone is often divided into two parts in the *quadrumana;* one of these forms the lesser alæ, and anterior clinoid processes; the greater alæ, the posterior clinoid processes, and basilar fossa, are formed by the other portion.

The two parietal bones form a single piece in the *bat-kind.* The same circumstance occurs in the *carnivora,* in the *pig, tapir, hippopotamus,* and *horse.*

The frontal and parietal bones of the *elephant* become consolidated, at an early period, with all the other parts of the cranium; so as to form a bony cavity, in which no trace of sutures can be discerned. The parietal, occipital, and temporal bones are likewise joined at an early period into one piece in the *cetacea.*

The pig, hippopotamus, tapir, horse, seal, walrus, and the *rodentia,* have the os frontis divided by a middle suture into two portions.

That portion of the os temporis, which contains the tympanum, is separated from the rest of the bone by a suture, which is seldom completely united in the *dog, cat,* and *civet.* The cavity of the tympanum is also separated in the rodentia, and the os frontis remains divided into two portions. In the cetacea the parietal bones are joined at a very early period to the occipital and temporal, so that the five bones form only one. The bone of the ear is always separated, and is merely attached to the cranium by soft parts. In the *elephant* this bone is also distinct and separated from the temporal.

The cranium of the mammalia possesses the same fossæ at its basis, as are found in the human subject: they are however much shallower; and the eminences which define them are much less strongly marked than in man. This difference is very perceptible even in the *simiæ,* where the cavities which hold the cerebellum are nearly on a level with the middle fossæ of the basis cranii; and the sella turcica is more superficial. The same fact is more strongly marked as we arrive at those animals, whose general structure deviates more considerably from that of man. Those mammalia, which have the *occipital foramen* situated at the back of the head, must have the *fossæ cerebelli* moved upwards; hence, that margin of the fossæ, which is posterior in man, passes across the upper part of the back of the head in these animals.

The optic foramina of the elephant commence from one canal, which receives the two optic nerves.

The foramen rotundum is sometimes absent, its place being supplied by the spheno-orbitar fissure, *(foramen lacerum)* e. g. in the *elephant* and *horse.* The foramen ovale is also frequently wanting; being included perhaps in the space left between the petrous por-

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1813, p. 4, the animal expression is particularly given to it by the shape of the forehead. This is of a triangular shape, and so compressed, that the upper edges of the plana semicircularia for the attachment of the temporal muscles are scarcely a thumb's breadth from each other.

tion of the temporal bone, and the body of the sphenoid. This latter opening does not exist in the *genus simia*, nor in the *carnivorous mammalia*, nor in the *ruminantia*. It is on the contrary very large in the *elephant*, and in some *rodentia*.

The carotid canal does not exist in the *rodentia*; but the artery enters at the opening between the sphenoid and temporal bones.

The structure of the cranium presents a very remarkable singularity in the *elephant*. Its two tables are separated from each other to a considerable extent by numerous bony processes; between which are formed a vast number of cells, communicating with the throat by means of the eustachian tubes, and filled with air, instead of the bloody or medullary substance which occupies the diplöe of animals. The use of this structure in increasing the surface for attachment of those large muscles which belong to the lower jaw, proboscis, and neck; and in augmenting the mechanical power of these muscles by removing their attachments to a greater distance from the centre of motion, has been very ingeniously explained by Camper, (*Œuvres*, tom. ii.). These advantages are attained by the cellular structure which we have just described, without augmenting the weight of the head, and this precaution is particularly necessary in the present instance, as the head is on other accounts more heavy and massy in this than in any other animal. The air cells of birds in general, and particularly those which pervade the cranium in the *ostrich*, *eagle*, and *owl*, present examples of a similar formation, attended with the same uses, viz. those of increasing the bulk and strength of the bone, and diminishing its weight.

§ 11. A principal variation in the form of the cranium arises from the size and direction of the *crista occipitalis*, which bears a determinate proportion to the strength of the jaws. It is wanting in most monkeys, but is very large in the baboon of Borneo.* The *longitudinal* crista is very strongly expressed in the *badger;* and the *transverse ridge* is remarkable in the *beaver*, and both in the *opossum*. Between the arched sides of the upper part of the cranium in the *elephant* lies a broad and deep impression, with a small longitudinal crista† at its bottom.

There is a considerable difference in this respect between the various races of dogs: as between the pug-dog and that of Newfoundland.

The crista occipitalis is a sharp, bony ridge, projecting from the upper and back part of the cranium in mammalia, chiefly for the attachment of the temporal muscle.

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* See G. Fischer's *Naturhistorische Fragmente*, vol. i. tab. 3, 4.

† See *Camper Descript. Anatomique d'un Elephant male*, tab. 13. fig. 6.

The size of the temporal fossa depends upon the magnitude of the muscle which it contains. Hence it is larger in the *carnivora* than in any other order; not only occupying the whole sides and upper part of the cranium, but being still further increased by prominent bony *cristæ*, growing from the frontal, parietal, and occipital bones. The two temporal muscles are indeed separated in many of these animals merely by the *parietal ridge*, which would completely cover the cranium.

These ridges are not so strongly marked in any animals as in the *carnivora;* yet they are discernible in most of the *simiæ*. They occur also in animals of the *pig kind*, and in the other *pachydermata*; the occipital crista is found where the others do not exist; as it serves for the attachment of the muscles of the neck.

§ 12. The situation and direction of the *great occipital foramen* are attended with remarkable variations in some instances. Instead of being situated far more anteriorly, and for the most part horizontally, as in the human subject,* (in which indeed the anterior margin is sometimes higher than the posterior) it is placed, in most quadrupeds, at the base of the cranium, and obliquely, with the posterior border more or less turned upwards. In some, indeed, its direction is completely vertical; and in the *marmot of the Alps* its upper margin is turned more forwards than the lower.†

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* In the skull to which I have before alluded, this opening for the spinal marrow lies much further back than in any of the numerous apes and baboons with which I have compared it.

† See Daubenton, on *the different Situation of the great Occipital Foramen in Man and Animals*, in the *Mém. de l'Acad. des Sc. de Paris*, 1764, p. 568. On the difference, which we are now considering, this excellent zootomist founded his *occipital line*, which has been employed in the comparison of different crania with each other. He draws two lines, which intersect each other in the profile of the skull: one passes from the posterior margin of the *great foramen*, (which, in almost all mammalia, is also the superior one,) through the lower edge of the orbit; the other takes the direction of the opening itself, beginning at its posterior edge, and touching the articular surface of the condyles. He determines according to the angle formed by the junction of these two lines, the similarity or diversity of the form of crania.

This angle is, however, but an imperfect criterion; for its variations are included between 80° and 90° in almost all quadrupeds, which differ very essentially in other points; and small variations occur in the individuals of one and the same genus.

The variations in the situation of the occipital foramen are important, when viewed in connexion with the ordinary position of the animal's body. In man, who is designed to hold his body erect, this opening is nearly equi-distant from the anterior and posterior extremities of the skull. The head, therefore, is supported in a state of equilibrium on the vertebral column. The angle, formed by the two lines mentioned by Daubenton, is only of three degrees.

Quadrupeds have the occipital foramen and condyles situated farther back, in proportion as the face is elongated. That opening, instead of being nearly parallel to the horizon, forms a considerable angle with it; which, measured according to Daubenton, is of 90 degrees in the *horse.* The weight of the head in these animals is not therefore sustained by the spine; but by a ligament of immense strength, which is either entirely deficient, or so weak, as to have its existence disputed in the human subject. This *ligamentum nuchæ,* or *cervical ligament,* arises from the spines of the dorsal and cervical vertebræ, (which are remarkably long for that purpose,) and is fixed to the middle and posterior part of the occipital bone. It is of great size and strength in all quadrupeds, but most particularly in the *elephant;* where the vast weight of the head, so much increased by the enormous size of the tusks, sufficiently accounts for its increased magnitude. It is bony in the mole, probably on account of the use which the animal makes of its head, in disengaging and throwing up the earth.

Animals of the genus *simia* and *lemur* hold a middle rank between man, who is constantly erect, and quadrupeds, whose body is supported by four extremities. Their structure is by no means calculated, like that of man, for the constant maintenance of the erect posture; but they can support it with greater facility and for a longer time than other animals. Hence, in the *orang-outang,* the occipital foramen is only twice as far from the jaws as from the back of the head, so that Daubenton's angle is only 37°. It is somewhat larger in the other species of *simiæ*; and measures 47° in the *lemur.*

§ 13. The true sutures, which connect the individual bones of the cranium, are generally less intricate, at least to outward appearance, in quadrupeds than in man. Their indentations are very strong and sharp in the *horned pecora,* for obvious reasons; and the frontal bones are thick in the same animals. In sheep, affected with the staggers, where the hydatid is large, and situated at the surface of the brain, I have found this part of the bone almost completely absorbed; so that it yielded to pressure, and appeared like a thin cartilaginous membrane. The *ossicula wormiana* are seldom seen in the crania of animals, yet I have specimens of these in the *hare,* and a young *oraug-outang;* the sutures of the latter are remarkably elegant. The observation, therefore, which Eustachius makes (*Ossium Examen*, p. 173), concerning the sutures of apes, namely, that " they are always so obscure, as scarcely ever to deserve the name of sutures," must be understood with some limitations.

§ 14. The general form of the cranium is most materially influenced by the direction, and the various degrees of prominence of the facial bones. The projection is generally formed by a prolongation of the upper jaw; partly also, and in many instances chiefly, by the *os intermaxillare*, which is inclosed between the two upper jaw-bones. To determine this with greater precision, Camper instituted the *facial line*, the application of which is most minutely explained in his posthumous work, " *On the Natural Differences of the Features*," &c. Like Daubenton, he draws on the profile of the cranium two straight lines, which intersect each other; but in different directions from those of the French anatomist. A horizontal line passes through the external auditory passage, and the bottom of the cavity of the nose; this is intersected by a more *perpendicular* one, proceeding from the convexity of the forehead, to the most prominent point of the upper jaw, or of the intermaxillary bone. The latter is the proper *facial line;* and the angle, which it forms with the horizontal line, determines, according to Camper, the differences of the crania of animals, as well as the national physiognomy of the various races of mankind.

I have mentioned my objections to its application, in the latter point of view, in my work, *De Generis Húmani Variet. Nativ.* 3d edit. p. 200. Concerning its use, as applied to the crania of animals, the same observations which were made on the line of Daubenton will hold good, *mutatis mutandis.* About three-fourths of all the species of quadrupeds, which we are hitherto acquainted with, whose crania differ extremely in other respects, have one and the same facial line.

The two organs which occupy most of the face, are those of smelling and tasting, (including those of mastication, &c.). In proportion, as these parts are more developed, the size of the face, compared to that of the cranium, is augmented. On the contrary, when the brain is large, the volume of the cranium is increased in proportion to that of the face. A large cranium and small face indicate therefore a large brain, with inconsiderable organs of smelling, tasting, masticating, &c.; while a small cranium, with a large face, shew that these proportions are reversed.

The nature and character of each animal must depend considerably on the relative energy of its different functions. The brain is the common centre of the nervous system. All our perceptions are conveyed to this part, as a *sensorium commune:* and this is the organ by which the mind combines and compares these perceptions, and draws inferences from them; by which, in short, it reflects and thinks. We shall find that animals partake in a greater degree of this latter faculty, in proportion as the mass of medullary substance, forming their brain, exceeds that which constitutes the rest of the nervous system; or, in other words, in proportion as the organ of the mind exceeds those of the senses. Since then, the relative proportions of the cranium and face indicate also those of the brain, and the two principal external organs, we shall not be surprised to find that they point out to us, in great measure, the general character of animals, the degree of instinct and docility which they possess. Man combines by far the largest cranium with the smallest face; and animals deviate from these relations in proportion as they increase in stupidity and ferocity.

One of the most simple methods (though sometimes indeed insufficient,) of expressing the relative proportions of these parts, is by means of the facial line, which has been already described. This angle is most open, or approaches most nearly to a right angle in the human subject; it becomes constantly more acute, as we descend in the scale, from man; and in several birds, reptiles, and fishes, it is lost altogether, as the cranium and face are completely on a level. The idea of stupidity is associated, even by the vulgar, with the elongation of the snout: hence the stupidity of the *crane* and *snipe* has become proverbial. On the contrary, when the facial line is elevated by any cause which does not increase the capacity of the cranium, as in the *elephant* and *owl*, by the cells which separate the two tables, the animal acquires a particular air of intelligence, and gains the credit of qualities which he does not in reality possess. Hence the latter animal has been selected as the emblem of the goddess of wisdom. The invaluable remains of Grecian art shew that the ancients were well acquainted with these circumstances; they were aware that an elevated facial line formed one of the grand characters of beauty, and indicated a noble and generous nature. Hence they have extended the facial angle to 90° in the representation of men on whom they wished to bestow an august character, and in the representations of their gods and heroes they have even carried it beyond a right angle, and made it 100°.

It must, however, be allowed, that the facial angle is of chief importance in its application to the cranium of the human subject, and of the *quadrumana;* as various circumstances affect the conclusions which would result from employing it in other classes of mammalia. Thus in the *carnivorous*, and some of the *ruminating* animals, in the *pig*, and particularly in the *elephant*, the great size of the frontal sinuses produces an undue elevation of the facial line. In many of the *rodentia*, as the *hare*, &c., the nose occupies so large a space, that the cranium is thrown quite back, and presents no point on a front view, from which this line can be drawn.

The following are the angles formed by drawing a line along the floor of the nostrils, and intersecting it by another, which touches the anterior margin of the upper alveoli, and the convexity of the cranium (whether the latter point be concealed by the face or not).

European infant	90°
——— adult	85
Adult negro	70
Orang-outang	67
Long-tailed monkeys	65
Baboons	40 to 30
Pole-cat	31
Pug dog	35
Mastiff; the line passing along the outer surface of the skull	41
Ditto, inner ditto	30
Leopard; inner surface	28
Hare	30
Ram	30
Horse	23
Porpoise	25

In the 3d and 4th tables of Cuvier's *Tableau Elémentaire de l'Histoire Naturelle*, the crania of several mammalia are represented in profile; so as to afford a sufficient general notion of the varieties in the facial angle. A similar comparative view, in one plate, is given by White, in his account of the *Regular Gradation*, &c., from the work of Camper.

The mode of comparison instituted by Cuvier shews the relative proportions of the cranium and face much more satisfactorily than that of Camper. This learned naturalist makes a vertical section of the skulls of different races of men, and the various classes of animals, and then compares the relative proportion of the cavity of the cranium to that of the section of the face. In the European the area of the section of the cranium is four times as large as that of the face; the lower jaw not being included. The proportion of the face is somewhat larger in the *negro;* and it increases again in the *orang-outang*. The area of the cranium is about double that of the face in the *monkeys;* in the *baboons*, and in most of the *carnivorous mammalia*, the two parts are nearly equal. The face exceeds the cranium in most of the other classes. Among the *rodentia*, the *hare* and *marmot* have it one-third larger; in the *porcupine*, and the *ruminantia*, the area of the face is about double that of the cranium; nearly triple in the *hippopotamus*, and almost four times as large in the *horse*. In reptiles and fishes, the cranium forms a very inconsiderable portion of the section of the head; although it is considerably larger than the brain which it contains.

The outline of the face, when viewed in such a section as we have just mentioned, forms in the human subject a triangle, the longest side of which is the line of junction between the cranium and face. This extends obliquely backwards and downwards, from the root of the nose towards the foramen occipitale. The front of the face, or the anterior line of the triangle, is the shortest of the three. The face is so much elongated, even in the *simiæ*, that the line of junction of the cranium and face is the shortest side of the triangle; and the anterior one the longest. These proportions become still more considerable in other mammalia.

§ 15. The upper jaw-bones of other mammalia do not, as in man, touch each other under the nose, and contain all the upper teeth; but they are separated by a peculiar single or double *intermaxillary bone*,[*] which is in a manner locked between the former, and holds the incisor teeth[†] of such animals as are provided with these teeth. It exists also in the *pecora*, which have no incisor teeth in the upper jaw; as well as in such genera as have no incisor teeth at all, viz. the *duck-billed animal*, the *Cape ant-eater*, and the *armadillo*. It is even found in those mammalia which are wholly destitute of teeth, as the *ant-eater* and the proper *whales*.[‡] It is joined to the neighbouring bones by sutures, which run externally by the side of the nose and snout, and which pass, towards the palate, close to the foramina incisiva.[§] Its form and magnitude vary surprisingly in several orders and genera of mammalia. It is small in many feræ, as also in the *walrus* (*trichechus*). In many of the *glires*[*] it is remarkably large, viz. in the *beaver* and *marmot*. It is also large in the *hippopotamus*, *porpoise*, and *cachalot*, (*physeter macrocephalus*) and particularly projecting in the *wombat*. Its form is very remarkable in the *ornithorhynchus*, where it consists of two hook-like pieces, joined by a broad synchondrosis.[†]

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[*] Gotth. Fischer *on the different forms of the intermaxillary bone in different animals*, with plates. Leipzig, 1800, 8vo.; and Kool's *Annotationes Anatomicæ*. Gronig. 1800, p. 5.

[†] Vesalius *De c. h. fabrica*, p. 46, fig. 1.

[‡] On this account I prefer the term intermaxillary bone to that of *os incisivum*, which is employed by Haller. Blair, in his excellent account of the anatomy of the elephant, calls it *os palati*; and Vitet *os maxillaire intérieur*.

[§] In human crania, at least those of the fœtus and young children, there is at the same part a small transverse slit near the foramen incisivum, of which Fallopius gave the following accurate account in the year 1561: *Reperio hanc divisionem vel rimam potius esse, quam suturam; cum os ab osse non separet, neque in exterioribus appareat, vel cum os cum osse non conjungat, quod suturarum munus est.* "I find this to

The want of the *os intermaxillare* has been regarded as a chief characteristic of the human subject; as one of the leading circumstances which distinguish man from other mammalia. That this bone is really wanting in man must be allowed, notwithstanding the doubts of Vicq d'Azyr. The well-known transverse slit, behind the alveoli of the incisors in the human fœtus, would form a very slight and remote analogy between the human structure and that of animals; and when we consider, that the superior or facial surface of the maxillary bones, so far from being marked by any suture,

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be rather a division or fissure than a suture, since it does not separate one bone from the other, nor does it appear exteriorly, nor join two bones, which is the office of sutures." *Obs. Anat.* How far the alveolar portion of the superior maxillary bones marked by the fissure between them may be regarded as a rudiment of an intermaxillary bone, has been ably shewn by Göthe, in the 1st vol. of his *Morphologie*. Compare Vicq d'Azyr. *Mém. de l'Acad. des Sc.* 1780, and *Const. Nicati de Labii leporini congeniti Natura et Origine.* Ultraj. p. 25.

In the celebrated dispute of the 16th century, whether Galen's osteology was derived from the skeleton of man or the ape, Ingrassias argued for the latter side of the question, from Galen's having ascribed an intermaxillary bone to the human subject: and the same author, in his classical *Commentarii in Galeni Librum de Ossibus*, Panorm, 1603, fol. particularly points out the parts " where Galen, led astray by the dissection of apes, deviates from the true construction of the human body."

[*] Its great size in these animals is accounted for by the magnitude of the incisor teeth which it contains.

[†] I cannot repeat here what I have observed in my book *De Generis Huma. Var. Nat.* on the subject of the intermaxillary bone; of which, as is there stated, not the least trace could be discovered in the crania of some *apes* and *baboons*, although the individuals were young. It must be inferred, that in these instances, it was consolidated to the neighbouring bones in their fœtal state, when all the other sutures were nevertheless in a state of perfection.

Fischer could discover no trace of this bone in several mammalia of other orders, viz. the *three-toed sloth*, (*bradypus tridactylus*) and the *horse-shoe bat*, (*vespertilio ferrum equinum*). See his work above quoted, and Geoff. Hilaire, in his *Description de l'Egypte*, who found no trace of the intermaxillary bone in the *vespertilio perforatus.*

does not even bear a slit like that of the inferior part, it must be put entirely out of the question.

That all other mammalia possess this bone, is not quite so clear as that it is wanting in man. The exceptions occur in the quadrumana. In addition to those which the author has stated, it may be observed, that the head of an *orang-outang*, in the Hunterian Museum, which possesses all the other sutures, wants those which separate the intermaxillary bone. Tyson did not find this bone in his specimen of the animal, which was very young, (see his *Anatomy of the Pigmy*) and it did not exist in a cranium which was delineated by Daubenton. I have also seen the crania of other monkeys, in which the sutures were all perfect and distinct, although this bone was wanting.

§ 16. The above-mentioned *anterior palatine holes*, or *foramina incisiva* are double in most mammalia, as in man. They are much larger in quadrupeds than in the human subject: in the *pecora* and the *hare* they are remarkably long and broad.*

§ 17. There are remarkable impressions on the outer side of the upper jaw of most *pecora*, near to the nasal bones, arising from the situation of the *sinus sebacei*. This part has a reticular structure in the *hare*, which approximates in that, as well as in many other points, to the formation of the ruminant animals.

§ 18. In the *zygoma* we observe several important differences, immediately derived from the organs of mastication.† In many quadrupeds (especially the *digitata* and *palmata*,) the *processus malaris* of the superior maxillary bone runs in a long narrow process towards one similar in shape coming from the temporal, so that it occupies the situation of the malar bone in man. This bone is wedged in as a middle piece between these two processes, has nothing to do with the frontal, and consequently does not contribute to the formation of the orbits. The zygoma is straight, and almost of a thread-like slenderness in the mole. It is of immense strength, and includes a large space towards the cranium, for lodging the powerful muscles which move the lower jaw, in several *carnivorous animals,* as the *tiger,* and in some *glires,* as the *beaver.* In the *rat,* and some others, it is convex below; in the *weasel,* above. It is remarkable in the *sloth* for a large descending process, which comes from the os malæ.*

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* In many instances, as in the *lion*, the openings of these large foramina are very visible in the palate during life. See J. Ridinger's *Delineation of the tame Lion, which was exhibited in Germany in* 1760, fol.

† See Pinel, *Recherchés sur une Nouvelle Methode de Classification des Quadrupedes*, in the 1st vol. of the *Actes de la Société d'Histoire Naturelle de Paris*.

The zygoma is wanting in the *ant-eater,* in which the temporal and malar bones have only a slight projection instead of the usual zygomatic process. This circumstance is sufficiently explained by the want of teeth, and the consequent want of mastication. The zygomatic suture is so oblique in the *carnivora,* that the temporal bone forms the whole superior margin, and the *os malæ* the inferior edge of the zygoma.

The zygoma may be arched both in the vertical and horizontal directions. A curvature of the latter kind indicates the existence of a strong temporal muscle; while one of the former description shews that the masseter is large. Both these curvatures are considerable in the *carnivora.*

§ 19. The *elephant* possesses only a rudiment of the nasal bones. In most *apes,* and even in the *orang-outang,* there is a single, triangular, and very small nasal bone; in the *rib-faced baboon* (*papio mormon*) it is exceedingly long and narrow, and sinks between the long nasal processes of the superior maxillary bones. In the greater number of true quadrupeds, there are two ossa nasi, frequently of very considerable magnitude. This is the case in the *pecora* and *hare;* also in the *horse, pig,* &c. In the *rhinoceros,* the ossa nasi, which support the *horn,* are very soon consolidated together.

§ 20. Of the lacrymal bones also, (*ossa unguis*) there is merely a rudiment in the *elephant.* These bones are strikingly developed in the *bisulca,* especially in the *antelope,* and still more remarkably in the *opossum* (*didelphis marsupialis*).†

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* The two hedge-hogs (*erinaceus setosus* and *ecaudatus*) have indeed no malar bone, see Meckel's *Beyträge zur vergleichenden Anatomie,* I. B. I. Heft, p. 40.

† A peculiarity in the makis (the lemur tribe) is that in them the superior opening of the lacrymal duct lies external to the orbit; see Fischer's *Anatomie der maki,* I. B. Frankf. 1804, iv. p. 6.

§ 21. The orbits differ very much in their direction, capacity, and depth. They have for the most part a lateral direction. In the *simiæ* they are directed forwards, as in man; but they lie much more closely together than in the human subject. In the *beaver* they point upwards.

They are completely closed in the quadrumanous mammalia. In the *pecora* and *solidungula* they have a circular margin in front; but the external wall is deficient behind. In most of the *feræ*, and in several *glires*, the outer part of their margin is also deficient. The depth of these cavities is equally various. In many cases they are so superficial as scarcely to deserve the name of orbit; viz. in the *mole* and *ant-eater*. Haller's assertion, that man possesses a larger bony orbit than any animal, is erroneous. The orbit of the *cat* is comparatively larger, as also that of several *makis* (*lemures*). See the delineation of their crania in Fischer's valuable work above quoted, *Anatomy of the Maki*. Frankfort, 1804, 4to.

The interval between the orbits is always smaller in the simiæ than in the human subject. In several of these, as in the monkeys, properly so called, the two orbits are separated at their posterior part by a simple bony septum. In other mammalia these cavities are thrown towards the side of the head, and to a great distance from each other, by the ascending or nasal processes of the upper jaw-bones, which are very large.

In those mammalia, which have the orbit open at its outer and back part, so as to communicate with the temporal fossa (such as the *carnivora*, *rodentia*, *edentata*, and *pachydermata*) the os malæ merely contributes to the formation of the zygoma, without being connected to the frontal or sphenoid bones. The superior maxilla merely forms the anterior border of the cavity, without constituting the floor of the orbit, which is indeed open below. The ossa palati, which are large, form a considerable share of the inner part of the cavity; the ethmoid bone not contributing to it.

The *ruminating animals*, as well as the *horse* and *ass*, have the margin of the orbit completed at its outer part by a bony circle, although the cavity is open behind to the temporal fossa.

The *mole* has not, properly speaking, an orbit. Its diminutive eyes, the very existence of which was for a long time questioned, lie under the integuments. Blumenbach's *Beschreibung der Knocken*, p. 225, note. The same observation holds good of the *myrmecophaga didactyla*. Ibid.

The organ of vision is present without exception, only in one class of animals, namely, in birds. In the mammalia we have two instances of complete blindness, namely, in the *blind rat* (*spalax typhlus, Pall. Mus typhlus, L.*) and in a variety of the *mole* (*chrysochlorus, sorex aureus*). In both these animals a hairy curtain, in which there is no fissure, is continued over the shrivelled eyes. Rudolphi, *Physiologie*, vol. ii. p. 154.

§ 22. In mammalia which have horns, these parts grow on particular processes of certain bones of the cranium. In the *one-horned rhinoceros* they adhere to a rough, and slightly elevated surface of the vast nasal bone. The front horn of the two-horned species has a similar attachment; the posterior rests on the os frontis;* as those of the horned pecora do. Two kinds of structure are observed in the latter: there are either proper horns, as in the genera of the *ox, goat,* and *antelope,* or bony productions, as in the genus *cervus,* which includes animals of the deer kind. In the former, the external table of the frontal bones is elongated into one process, and in the *ovis polycerata,* into several. In the greater number of these the frontal sinusses extend into the horny processes. The antelopes have been in general excepted. But that this exception does not hold good of all the species of this tribe, appears from the horn of an *antelope bubalis* in my collection, the bony process of which is hollow and connected with the frontal sinusses. The external vascular surface of the process secretes the horn, which covers it like a sheath. In the stag kind (in the male only in most genera), the frontal bone forms a short flattened prominence, from which the proper *antler* immediately shoots forth. It is renewed every year, and is covered, during the time of its growth, with a hairy and very vascular skin. The little horns of the *giraffe* hold a middle place between these two divisions. In their form, structure, and permanent duration, they resemble the frontal processes of the proper horns: in their hairy covering they approach to the branches of the stag kind.†

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* Geoffroy, in *Mémoires de la Société d'Histoire Naturelle de Paris,* an 7. cahier 1.

† Anomalous instances, in which the females have possessed horns, may be seen in Stahl *De Cornu Cervi deciduo,* Hal. 1699. Leopold, *Diss. de Alce,* Bas. 1700. Hoy in the *Linnean Trans.* vol. ii. p. 356.

I have collected about twenty instances, from the middle of the sixteenth century downwards, in which *horned hares* are said to have been found, with small branches like those of the *roebuck,* both in different parts of Europe, and in the East Indies. Were this fact ascertained, it would furnish another striking point in which these animals resemble the *pecora.* The fact is suspicious, because I have not yet been sufficiently satisfied of a single instance in which the horns were on the hare's head, although every trouble has been taken to procure information; and they appear in the drawings, which I possess, by far too large for a hare.

The annual reproduction of horns constitutes, in many points of view, one of the most remarkable phenomena of animal physiology. It affords a most striking proof, 1st, of the power of the nutritive process, and of the rapid growth which results from this process in warm-blooded animals; for the horn of a stag, which may weigh a quarter of a cwt. is completely formed in ten weeks: 2ndly, of the remarkable power of absorption, by which, towards the time of shedding the old horn, a complete separation is effected of the substance, which was before so firmly united with the frontal bone: 3rdly, of a limited duration of life in a part of an animal, entirely independent on the life of the whole animal, which in the stag extends to about thirty years: 4thly, of change of calibre in particular vessels; for the branches of the external carotid, which supply the horn, are surprisingly dilated during its growth; and recover their former dimensions when that process has ceased: 5thly, of a peculiar sympathy, which is manifested between the growth of the horns and the generative functions; for castration, or any essential injury of the organs of generation, impedes the growth, alters the form, or interrupts the renewal of the horns.* It has also been asserted, but without a sufficient proof hitherto, that injuries of the newly formed horn render the stag impotent for some time.

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* See Russell's experiments in his *Economy of Nature in Acute and Chronical Diseases of the Glands*: *Berlin Soc. of Inquirers into Nature,* vol. iv. p. 360, and Dr. Paris, in the *Transac. of the Linnean Society,* vol. x. part II. p. 211.

The word *horn*, which is frequently applied in English to the *antlers* of the deer kind, as well as to the real horns of other genera, would lead to very erroneous notions on this subject. The *antler* is a real *bone;* it is formed in the same manner, and consists of the same elements as other bones; its structure is also the same.

It adheres to the frontal bone by its basis; and the substance of the two parts being consolidated together, no distinction can be traced, when the antler is completely organized. But the skin of the forehead terminates at its basis, which is marked by an irregular projecting bony circle; and there is neither skin nor periosteum on the rest of it. The time of its remaining on the head is one year: as the period of its fall approaches, a reddish mark of separation is observed between the process of the frontal bone and the antler. This becomes more and more distinctly marked, until the connexion is entirely destroyed.

The skin of the forehead extends over the process of the frontal bone, when the antler has fallen: at the period of its regeneration, a tubercle arises from this process, and takes the form of the future antler, being still covered by a prolongation of the skin. The structure of the part at this time is soft and cartilaginous; it is immediately invested by a true periosteum, containing large and numerous vessels, which penetrate the cartilage in every direction, and by the gradual deposition of ossific matter, convert it into a perfect bone.

The vessels pass through openings in the projecting bony circle at the base of the antler; the formation of this part, proceeding in the same ratio with that of the rest, these openings are contracted, and the vessels are thereby pressed, until a complete obstruction ensues. The skin and periosteum then perish, become dry and fall off; the surface of the antler remaining uncovered. At the stated period it falls off, to be again produced, always increasing in size.

The horn is shed in the spring, and re-produced in the summer; during the interval the male and female abstain from copulation. When the rutting season, which lasts three weeks, commences, large troops of the males and females re-assemble, and continue together during the winter.

§ 23. The skeleton of quadrupeds deviates more from that of man in the form of the lower jaw-bone, than in any other part. This difference consists chiefly in the want of a prominent chin; that peculiar characteristic of the human countenance, which exists in every race of mankind, and is found in no other instance whatever. Man has also the shortest lower jaw in comparison with the cranium; the elephant perhaps approaching the nearest to him in this respect.* The same bone is further distinguished by the peculiar form and direction of its condyle. The articulation of these processes varies according to the structure of the masticating organs. They are both situated in the same straight horizontal line in the *feræ;* their form is cylindrical; and they are completely locked in an elongated glenoid cavity, whose margins are so extended before and behind the condyle, that all rotatory motions are rendered impossible, and hinge-like movements only allowed. This structure is most strikingly exemplified in the *badger,* where the cylindrical condyles are so closely embraced by the margins of the articular cavity, that the lower jaw (at least in the adult animal), is still retained in its situation, after the soft parts have been entirely removed by maceration. In many herbivorous animals (in the most extensive sense of the term) these condyles are really rounded eminences; viz. in the *elephant* and *beaver.* Their surface is flattened in the *pecora,* which have also the lower jaw narrower than the upper, so that the two sets of teeth do not meet together, when the mouth is shut, but are brought into contact by the free lateral motion, which takes place in rumination. The two condyles lie parallel to each other in a longitudinal direction in many *glires;* viz. in the *hare,* where (as in the *ant-eater*) the coronoid process is almost entirely wanting. This process is on the contrary very conspicuous in the *giraffe.* The *cetacea* have the articular surface of the lower jaw turned almost directly backwards.†

There are, on the whole, few other bones in the skeleton of mammalia, of such various forms as the lower jaw. The most anomalous formation of this bone is the shovel-like surface of its anterior part in the *duck-billed animal:* to which may be added the very strong horizontal processes on the under side of the lower jaw in the *wombat*, and the strikingly large lateral portions of this bone in the *Brazilian monkeys (cercopithecus seniculus and Belzebub)* between which the bony cavity of the larynx is situated, which enables them to emit a peculiar deafening sound.

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* See Pinel *Sur les Os de la Tête de l'Elephant* in the *Journal de Physique,* tom. xliii. p. 54.

† The singular, but very common error, of considering the halves of the lower jaw of the whale as ribs has been already refuted by Rondelet, *De Piscibus,* p. 53,

We have lastly to observe that the two halves of the lower jaw are connected throughout life, in many mammalia, by a mere synchondrosis; which is easily separated by boiling or maceration. This is the case in many *feræ, glires*, and *cetacea*. They are consolidated into one piece, as in the human subject, at an early period, in the *quadrumana*, as also in the *horse, horned cattle, pig, elephant*, &c.

As the motions of the lower jaw must be materially influenced by the form of its condyle, and by the manner in which that process is connected to the articular cavity of the temporal bone; we shall find, as might have been expected, a close relation between these circumstances and the kind of food by which an animal is nourished. Thus the lower jaw of the carnivora can only move upwards and downwards, and is completely incapable of that horizontal motion which constitutes genuine mastication. Hence these animals cut and tear their food in a rude and coarse manner, and swallow it in large portions, which are afterwards reduced by the solvent properties of the gastric juice. Such mammalia, on the contrary, as live on vegetables, have, in addition to this motion, a power of moving the lower jaw backwards and forwards, and to either side; so as to produce a grinding effect, which is necessary for bruising and triturating grass, and for pulverising and comminuting grains. In all these, therefore, the form of the condyle, and of its articular cavity, allows of free motion in almost every direction. The teeth may be compared, in the former case, to scissars; in the latter, to the stones of a mill.

§ 24. The jaws of mammalia contain teeth* with a very few exceptions: the proper whales, *(balænæ)* the *manis, (scaly lizard)* and the *American ant-eaters,* are the only genera entirely destitute of these organs.

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* See J. G. Duverney, *Lettre contenant plusieurs nouvelles Observations sur l'Osteologie*, Paris, 1689, 4to.

J. J. Kober *De Dentibus, eorumque Diversitate*, Argent. 1774, 4to.

P. M. G. Broussonet, *Comparaison entre les Dents de l'Homme et celles des Quadrupedes*, in *Mém. de l'Acad. des Sc. de Paris*, 1787.

Rob. Blake's *Essay on the Structure and Formation of the Teeth in Man and various Animals*, Dublin, 1801-8, and particularly Fr. Cuvier *des Dents des Mammifères*, Par. 1821-8.

The substance and texture of the teeth are different from those of all other bones. The enamel which covers the crown of the tooth is characterized by its peculiar hardness (sparks of fire may be produced by striking it against steel), as well as by the want of animal matter, with which the bony part of the crown as well as the fang of the tooth are copiously provided. It seems to be wanting in the tusks of the *elephant,* as also in those of the *walrus,* the *narwhale,* (*monodon, sea-unicorn*) and in the incisors of the African hog (*sus Æthiopicus*). Yet these are all surrounded by an external thin coat of a different substance from the body of the tooth. These teeth have indeed some peculiarity in their texture; the ivory of the elephant's tusks in particular is unlike any other substance. Not to mention other peculiarities of *ivory,* which have induced some modern naturalists to consider it as a species of *horn,* the difference between its structure and that of the bone of teeth is evinced in the remarkable pathological phenomenon, resulting from balls, with which the animal has been shot when young, being found on sawing through the tooth, imbedded in its substance in a peculiar manner. Haller employed this fact, both to refute Duhamel's opinion of the formation of bones by the periosteum, like that of wood by the bark of a tree; as well as to prove the constant renovation of the hard parts of the animal machine. It is still more important, in explanation of that "*nutritio ultra vasa,*" which is particularly known through the Petersburg prize dissertation. Instances of the fact abovementioned, in all which the balls were of iron, may be seen in several writers.* I possess a similar specimen: but there is a still more curious example in my collection, of a leaden bullet contained in the tusk of an East Indian elephant, which tusk must have been equal in size to a man's thigh, without having been flattened. It lies close to the cavity of the tooth; its entrance from without is closed as it were by means of a cicatrix; and the ball itself is surrounded apparently by a peculiar covering. The bony matter has been poured out on the side of the cavity in a stalactitic form.

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* Buffon, 4to. ed. tom. ii. p. 161, in Gallandat *over de Olyphants Tanden* in the *Verhandelingen der Genootfch, te Vlissingen,* p. 352, tom. ix.; and in Bonn's *Descr. thesauri Hoviani,* p. 146. Goethe's *Morphologie,* vol. ii. p. 7; and Cuvier's *Ossemens Fossiles,* tom. i. p. 48.

The organization of the molar teeth of the *Cape ant-eaters* is perfectly anomalous; they consist of vertical tubes. In some animals the crowns of particular teeth are distinguished by peculiar colours. The incisors of some *glires,* as the *beaver, marmot,* and *squirrel,* are of a nut-brown colour on their anterior surface, and the molar teeth of several *bisulca,* as well as of the elephant, are covered by a very hard black substance of a vitreous appearance. This black vitreous matter is sometimes covered with a crust of a metallic shining bronze colour; particularly in the domesticated horned cattle, and sheep.*

The teeth of the human subject seem to be designed for the single purpose of mastication; and hence an erroneous conclusion might be drawn, that they serve the same office in other animals. Many exceptions, however, must be made to this general rule. Some mammalia, which have teeth for the office of mastication, have others, which can be only considered as weapons of offence and defence, as the *tusks* in the *elephant, hippopotamus, walrus,* and *manati.* The large and long canine teeth of the *carnivora,* as the *lion, tiger, dog, cat,* &c. not only serve as natural weapons to the animal, but enable it to seize and hold its prey, and assist in the rude laceration which the food undergoes previous to deglutition. The *seal,* the *porpoise,* and other *cetacea,* as the *cachalot* (*physeter macrocephalus*) have all the teeth of one and the same form; and that obviously not calculated for mastication. They can only assist in securing the prey, which forms the animal's food.

Animals of the *genus balæna* (*the proper whales*) have, instead of teeth, the peculiar substance called *whalebone,* covering the palatine surface of the upper jaw: this resembles in its composition, hair, horn, and such substances.

The lower surface of the upper jaw forms two inclined planes, which may be compared to the roof of a house reversed; but the two surfaces are concave. Both these are covered with plates of the whalebone, placed across the jaws, and descending vertically into the mouth. They are parallel to each other, and exist to the number of two or three hundred on each of the surfaces. They are connected to the bone by the intervention of a white ligamentous substance, from which they grow; but their opposite edge, which is turned towards the cavity of the mouth, has its texture loosened into a kind of fringe, composed of long and slender fibres of the horny substance; which therefore covers the whole surface of the jaw. This structure probably serves the animal in retaining and confining the *mollusca* which constitute its food.

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* See Stobæus *De Inauratione spontanea dentium quorundam animalium,* in *Act. Liter. Suecic.* vol. iii. p. 83, 1733.

The teeth of the *ornithorhynchus paradoxus* and *hystrix* deviate very considerably from those of other mammalia. In the former animal there is one on each side of the two jaws: it is oblong, flattened on its surface, and consists of a horny substance adhering to the gum. There are likewise two horny processes on the back of the tongue: these point forwards, and are supposed by Sir Everard Home to prevent the food from passing into the fauces, before it has been sufficiently masticated. In the *hystrix*, there are six transverse rows of pointed horny processes at the back of the palate; and about twenty similar horny teeth on the corresponding part of the tongue.

See Sir Everard Home in the *Philos. Trans.* 1800, part 2; 1802 parts 1 and 2.

The substance composing the tusks of the elephant, commonly called ivory, is certainly different from the bone of other teeth. It is, generally speaking, more hard and compact in its texture; it is distinguished from all others by the curved lines which pass in different directions from the centre of the tooth, and form, by their decussation, a very regular arrangement of curvilinear lozenges. It soon turns yellow from exposure to the air. The tusk of the *hippopotamus* is harder and whiter; and consequently preferred for the formation of artificial teeth. In the *walrus*, the interior of the tooth is composed of small round portions, placed irregularly in a substance of different appearance, like the pebbles in the pudding stone; and the molar teeth have a similar structure.

The curious facts which Blumenbach has mentioned in this section have been sometimes brought forward to prove the vascularity of the teeth; a doctrine which is refuted by every circumstance in the formation, structure, and diseases of these organs. It may be first observed, that the appearances exhibited by the teeth in question are by no means what we should reasonably expect in such a case. When a bullet has entered the substance of the body, the surrounding lacerated and contused parts do not grow to the metal, and become firmly attached to its surface, but they inflame and suppurate in order to get rid of the offending matter. If the ivory be vascular and sensible, why do not the same processes take place in it?

We can explain very satisfactorily how a bullet may enter the tusk of an elephant, and become imbedded in the ivory without any opening for its admission being perceptible. It will be hereafter shewn that these tusks are constantly growing during the animal's life, by a deposition of successive laminæ within the cavity, while the outer surface and the point are gradually worn away; and that the cavity is filled for this purpose with a vascular pulp, similar to that on which teeth are originally formed. If a ball penetrate the side of a tusk, cross the cavity, and lodge in the slightest way on the opposite side, it will become covered towards the cavity by the newly deposited layers of ivory, while no opening will exist between it and the surface, to account for its entrance. If it have only sufficient force to enter, it will probably sink, by its own weight, between the pulp and tooth, until it rests at the bottom of the cavity. It there becomes surrounded by new layers of ivory; and as the tusk is gradually worn away, and supplied by new depositions, it will soon be found in the centre of the solid part of the tooth. Lastly, a foreign body may enter the tusk from above, as the plate of bone which forms its socket is thin; and if this descends to the lower part of the cavity, it may become imbedded by the subsequent formations of ivory. This must have happened in a case where a spear-head was found in an elephant's tooth. The long axis of the foreign body corresponded to that of the cavity. No opening for its admission could be discovered, and it is very clear that no human strength could drive such a body through the side of a tusk. *Philos. Trans.* 1801, part i.

§ 25. It is difficult to frame a classification of the teeth which shall be generally applicable, and at the same time intelligible. Their situation affords perhaps a more eligible basis of arrangement than their form, since that is the same throughout, in some instances, as in the *cachalot* and *porpoise*. They may therefore be distributed into the three classes of *front teeth*, *corner teeth*, and *back teeth*.

The front teeth are the *incisores* of Linnæus. The corner teeth are the *canini*, *laniarii*, of Linnæus; *cuspidati* of Hunter. The back teeth are the *molares*. The term of *tusks* is applied to such teeth as extend out of the cavity of the mouth.

§ 26. The front teeth in the upper jaw of quadrupeds and dolphins are those which are implanted in the intermaxillary bone; the front teeth in the lower jaw are such as correspond to these, or to the anterior margin of the intermaxillary bone in animals which have no upper incisors. Their number and form vary considerably. In the *glires* their cutting edge is formed like a chisel, particularly in the lower jaw, whence Grew called them *dentes scalprarii*. In some animals, as in the *beaver* and the *porcupine*, the lower ones have remarkably long roots: in many, as in the *marmot*, the upper ones also have long roots. In the hare there are two very small teeth placed just behind the large ones. The crowns of the front, as well as of the back teeth, form flat prominences in the walrus. The front extremity of the lower jaw, with its teeth, extends in the *dolphin* (*delphinus delphis*) much beyond the corresponding part of the upper jaw, contrary to what happens in other animals. The lower fore teeth of most mammalia have a more or less oblique position; while in man they are perpendicular. The *orang-outang* of Borneo is the only animal which in this respect at all approaches to the human subject.

The structure of the incisor teeth, in the *rodentia*, deserves attention on several accounts. They are covered by enamel only on their anterior or convex surface, and the same circumstance holds good with respect to the tusks of the *hippopotamus*. Hence, as the bone wears down much faster than this harder covering, the end of the tooth always constitutes a sharp cutting edge, which renders it very deserving of the name of an incisor tooth.

This partial covering of enamel refutes, as Blake has observed (*Essay on the Structure, &c. of the Teeth*, p. 212,) the opinion that the enamel is formed by the process of crystallization.

The incisor teeth of these animals are used in cutting and gnawing the harder vegetable substances; for which their above-mentioned sharp edge renders them particularly well adapted. Hence Cuvier has arranged these animals in a particular order by the name of *rodentia*, or the gnawers. As this employment subjects the teeth to immense friction and mechanical attrition, they wear away very rapidly, and would soon be consumed, if they did not possess a power of growth, by which this loss is recompensed.

These teeth, which are very deeply imbedded in the jaw, are hollow internally, like a human tooth, which is not yet completely formed. Their cavity is filled with a vascular pulp, similar to that on which the bone of a tooth is formed; this makes a constant addition of new substance on the interior of the tooth, which advances to supply the part worn down. The covering of enamel extends over that part of the tooth which is contained in the jaw, as we might naturally expect: for this must be protruded at some future period to supply the loss of the anterior portion. Although these teeth are very deeply implanted in the maxillary bones, they can hardly be said to possess a fang or root; for the form of the part is the same throughout; the covering of enamel is likewise continued; and that part, which at one period is contained in the jaw, and would form the fang, is afterwards protruded to constitute the body of the tooth.

The constant growth of these teeth, therefore, proceeds in the same manner, and is effected on the same principles as the original formation of any tooth, and can by no means furnish an argument for the existence of vessels in the substance of the part.

We cannot help being struck with the great size of these teeth, compared with the others of the same animal, or even with the bulk of the animal. Their length in the lower jaw nearly equals that of the jaw itself, although a small proportion only of this length appears through the gum. They represent the segment of a circle; and are contained in a canal of the bone, which descends under the sockets of the grinders, and then mounts up, in some instances, to the root of the coronoid process: hence, although their anterior cutting edge is in the front of the mouth, the posterior extremity is behind all the grinding teeth. No animal exhibits this structure better than the rat. The beaver also affords a good specimen of it on a larger scale. It has been drawn in this animal by Blake, (*Essay on the Structure, &c. of the Teeth,* tab. 9, fig. 3). The tooth does not extend so far in the upper jaw; it is there implanted in the intermaxillary bone, and terminates over the first grinder.

The observations which have been made respecting the constant growth of the incisor teeth of the *glires* will apply also to the tusks of the *elephant*. These are hollow internally, through the greater part of their length, and the cavity contains a vascular pulp, which makes constant additions of successive layers, as the tusk is worn down. One of the elephants at Exeter Change is said to have nearly bled to death from a fracture of the tusk, and consequent laceration of the vessels of the pulp. The tusks of the *hippopotamus*, and probably all other teeth of this description, grow in the same manner. Further and more accurate observation may hereafter shew, that the same mode of growth obtains also in other classes of teeth when they are exposed to great friction. Something similar may certainly be observed in the grinders of the horse. The tooth is not finished when it cuts the gum: the lower part of its body is completed while the upper part is worn away by mastication, and the proper fang is not added till long after. Hence we can never get one of these teeth in a perfect state; for if the part out of the gum is complete, the rest of the body is imperfect, and there are no fangs: on the contrary, when the fangs are formed, much of the body has been worn away in mastication. Blake further asserts that this structure is found in the grinders of the *beaver*, p. 99, tab. 9, fig. 4.

In the *delphinus Gangeticus*, of which there is a specimen in the Hunterian collection, presented by Sir J. Banks, the change that takes place in the form of the tooth, as it wears away from long use, is more remarkable than in most other teeth; for the perfect tooth has a tolerably sharp enamelled point, while the half-worn one has a curved, blunted, cutting edge. See Sir Ev. Home's description of the teeth of the *delphinus Gangeticus*, *Phil. Trans.* 1818, part 1, p. 417.

§ 27. The corner teeth (*canini*) of the upper jaw lie close to the intermaxillary bone; hence the remarkable spiral tusk of the *narwhale*,* and the tusks of the *walrus* belong to this division. In many *baboons*, and most particularly in the larger predacious mammalia, these teeth are of a terrific size: in the latter animals, the whole profile of the anterior part of the cranium forms a continuous line with these teeth, which is very visible in the *tiger*. The canine tusks of the *babiroussa*, which are very long, and curved so as nearly to describe a complete circle, present the most curious structure. Their utility to the animal appears quite obscure, when their length, direction, and smallness are considered. The small canine teeth, which are situated just behind the larger ones, in all the species of the deer and bear kind, are also remarkable. This is the case in the brown bear of the Alps, of which I have three crania; in a black American; in one whose country is unknown, belonging to the national Museum at Paris; and in the Polar bear; of all which I possess excellent drawings, through the kindness of Professor Cuvier. These small teeth are wanting in the fossil remains of an ante-diluvian bear, (*ursus spelæus*) towards the illustration of whose osteology I have a large collection, from the four most celebrated caverns in Germany, viz. that of Scharzfelder in the Harz, of Gailenreuter in the Fichtelberg, of Altensteiner in Thuringerwald, and of Sunwicher in Iserlohn.

The narwhale is found so constantly with only one tusk, that it has been called the sea-unicorn, and Linnæus has even given it a similar appellation, that of *monodon*. Yet there can be no doubt that it possesses originally two of these; one in either jaw-bone; and that which is wanting must have been lost by some accidental circumstance, as we can easily suppose, (Shaw's *Zoology*, vol. ii. p. 473). These tusks often equal in length that of the animal's body; which may be eighteen feet or more; yet they are always slender.

The result of Sir E. Home's examination of two specimens of the male narwhale in the Hunterian collection, and of a female sent to him by Mr. Scoresby, was, that the left tusk of this animal appears commonly long before the right one, and that the tusks in the female come much later than in the male, which facts explain the error of Linnæus, and that of the captains of the Greenland ships, who supposed that the females had no tusks.

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* I must refer to the 5th part of my *Delineations of Subjects relating to Natural History*, for what is there said on the question, whether the *narwhale* has really one or two of these teeth.

§ 28. The back teeth are the most universal; since, when mammalia have any teeth at all, they are of this description, although the front and canine teeth may be wanting, as in the *armadillo* and the *ant-eater*. The *narwhale* makes the only exception, as it is perfectly toothless, if we except the long tusk. The form, structure, and relative situation of the back teeth vary very considerably. In many *quadrumana* and in man the two front ones* are smaller in the crown, and more simple in the fang than the posterior: whence J. Hunter calls them *bicuspides*, and restricts the name of *molares* to the latter.†

The molar teeth of *feræ* and of man have the crown entirely covered with enamel: this is the case also in the monstrous fossile *animal incognitum* of the Ohio, (*mammut Ohioticum*) which has been called the carnivorous elephant.‡ In several *glires*, (in some, as the *marmot*, the whole crown is covered with enamel) in the *solidungula*, *pecora*,§ and most *balænæ*, bony substance may be seen at the extremity of the tooth, intermixed in a tortuous line with vertical productions of enamel.* In many animals which feed on grass, and do not ruminate, as the *solidungula* and the *elephant*, the broad crowns of the grinding teeth lie chiefly in a horizontal direction towards each other. In most *pecora*, on the contrary, their surface, which forms a zig-zag line, is oblique; the outer margin of the upper teeth and the inner margin of the lower teeth being the most prominent. In most predacious animals, particularly of the *lion* and *dog* kind, the crowns of the molar teeth are compressed, and terminate in pointed processes, the lower ones shutting within the upper; so that in biting they intersect each other, like the blades of a pair of scissars, in consequence of the firm hinge-like articulation of the cylindrical condyle.

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* In some *apes* and *baboons*, the front bicuspis of the lower jaw has a peculiar formation, being elevated into a sharp point, like those of the *feræ*. See the excellent representation of the cranium of the mandril (*simia maimon*) in Cheselden's *Osteography*.

† I find that the difference between the bicuspides and molares is noticed in the first anatomical compendium, which was compiled from human bodies, viz. the celebrated *Anatomia partium Corp. Human.*, written by Mondini, in the first half of the fourteenth century. For he enumerates in each jaw four *maxillares*, and six *molares*, besides the incisor and canine teeth, p. 370, of the classical edition, which is accompanied with Berengar's Commentaries. I have also found, that this distinction of the two kinds of grinders is noticed in that famous volume of admirable anatomical drawings, by the incomparable Leonardo da Vinci, which is preserved in his majesty's library.

‡ See the 2nd part of *Delineations of Subjects relating to Natural History*, tab. 19.

§ For the internal structure of the molar teeth of *pecora*, see Hollmann *De Ossibus Fossilibus*, in the *Commentar. Reg. Soc. Scient. Götting.* tom. ii. p. 263, and Schreger, in Isenflamm's and Rosenmuller's *Contributions towards Anatomy*, vol. i. part i. p. 5.

The distribution of the enamel and bony substance varies in the teeth of different animals, and even in the different orders of teeth in the same animal.

All the teeth of the *carnivora*, and the incisors of the *ruminating animals*, have the crown only covered with enamel, as in the human subject. The immense fossil grinders of the *animal incognitum*, or *mammoth*, have a similar distribution of this substance.

The grinders of graminivorous quadrupeds, and the incisors also of the horse, have processes of enamel descending into the substance of the tooth. These organs have also in the last-mentioned animals a third component part, differing in appearance from both the others, but resembling the bone more than the enamel. Blake has distinguished this by the name of *crusta petrosa;* and Cuvier calls it *cement.*

The physiological explanation of this difference in structure is a very easy and clear one. The food of the *carnivora* requires very little comminution before it enters the stomach: hence, the form of their molar teeth is by no means calculated for grinding; and, as the articulation of the jaw admits no lateral motion, these teeth, of which the lower are overlapped by the upper, can only act like the incisors of other animals. The food of graminivorous quadrupeds is subject to a long process of mastication, before it is exposed to the action of the stomach. The teeth of the animals suffer great attrition during this time, and would be worn down very rapidly but for the enamel which is intermixed with their substance. As this part is harder than the other constituents of the teeth, it resists the attrition longer, and presents the appearance of prominent ridges on the worn surface, by which the grinding of the food is much facilitated.

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* The specifically different forms of the layers of enamel, in the *African* and *Asiatic elephants,* may be seen in the *Delineations,* &c. part ii. tab. 19.

The distinction of the three substances is seen better in the tooth of the elephant than in any animal. The best method of displaying it is by making a longitudinal vertical section, and polishing the cut surface. The *crusta petrosa* will then be distinguished by a greater yellowness and opacity in its colour; and by an uniformity in its appearance, as no laminæ or fibres can be distinguished.

The pulp of a grinding tooth of a graminivorous quadruped is divided into certain conical processes, which are united at their bases. These vary from two to six in the *horse* and *cow*. On these the bone of the tooth is formed, as on the single pulp of the human subject, but it is here divided into as many separate shells as there are processes of the pulp; all of them, however, enclosed in a common capsule. The ossification commences, as in all teeth, on the points of the pulp, and extends towards the basis: when it has arrived there, the shells unite together; and they also join at their outer margins Between the processes of the pulp other productions descend from the capsule in a contrary direction; and deposit, on the surface of the shells, enamel distinguishable by its crystalline appearance, and hence denominated by Blake *cortex striatus*. When these membranous productions have formed their portions of enamel, they secrete the *crusta petrosa* within the cavities left between them. The outer surface of the bone of the tooth is covered by enamel, which may be compared to that which invests the crown of a human tooth, except that it is deposited in an irregular waving line, in order to render the surface better calculated for grinding; and the inequalities of this surface of enamel are filled up by *crusta petrosa*. The exterior enamel, and *crusta petrosa*, (which may be so named, by way of distinguishing them from the processes within the tooth) are formed by the surface of the capsule.

If, then, we make a transverse section of a grinding tooth of the *horse* or *cow*, the exterior surface will be found to consist of an irregular layer of *crusta petrosa:* this is succeeded by a waving line of *enamel*, within which is the proper *bone of the tooth*. But the substance of the latter is penetrated by two productions of enamel; in the interior of each of which is *crusta petrosa*.

The *crusta petrosa*, which fills these internal productions of enamel, is sometimes not completely deposited before the tooth cuts the gum: hence, cavities are left in the centre of the tooth, which become filled with a dark substance composed of the animal's food, and other foreign matters. This seldom happens to any considerable extent in the grinders of the *horse*. In the *cow* and *sheep* these cavities are constantly filled with the dark adventitious matter; the *crusta petrosa* being confined to the exterior surface of the tooth, and not existing even there so plentifully as in the horse.

The lower grinders of the horse differ very much in their formation from those of the upper-jaw. Ossification commences in these by four or five points, which increase into as many small shells; yet they unite without any processes of the capsule passing down between to form internal productions of the *enamel*. This substance is however deposited in a very convoluted manner on the bone of the tooth, so that the same end is attained, as if productions of the *cortex striatus* had existed in the centre of the part. The *crusta petrosa* fills up the irregularities of this waving line of enamel. A horizontal section of such a tooth presents the three substances arranged within each other: the *crusta petrosa* is external; then comes the enamel, which includes nothing but the proper bone of the tooth.

The incisors of the horse have a production of *enamel* in their centre; but the cavity which this forms containing no *crusta petrosa*, is merely filled by the particles of food, &c. As these processes of enamel descend only to a certain extent in the tooth, they disappear at last from the constant wear of the part in mastication; and this is improperly called the filling up of the teeth. Hence a criterion arises of the horse's age.

The grinding teeth of the elephant contain the most complete intermixture of the three substances, and have a greater proportion of *crusta petrosa* than those of any other animal. The pulp forms a number of broad flat processes, lying parallel to each other, and placed transversely between the inner and outer laminæ of the alveoli. The bone of the tooth is formed on these in separate shells commencing at their loose extremities, and extending towards the basis where they are connected together. The capsule sends an equal number of membranous productions, which first cover the bony shells with *enamel*, and then invest them with *crusta petrosa;* which latter substance unites and consolidates the different portions. The bony shells vary in number from four to twenty-three, according to the size of the tooth, and the age of the animal: they have been described under the term of denticuli, and have been represented as separate teeth in the first instance. It must, however, be remembered, that they are formed on processes of one single pulp.

When the *crusta petrosa* is completely deposited, the different denticuli are consolidated together. The bony shells are united at their base to the neighbouring ones; the investments of enamel are joined in like manner; and the intervals are filled with the third substance, which really deserves the name bestowed on it by Cuvier, of *cement*. The pulp is then elongated for the purpose of forming the roots or fangs of the tooth. From the peculiar mode of dentition of the elephant, the front portion of the tooth has cut the gum, and is employed in mastication, before the back part is completely formed, even before some of the posterior denticuli have been consolidated. The back of the tooth does not appear in the mouth until the anterior part has been worn down even to the fang.

A horizontal section of the elephant's tooth presents a series of narrow bands of bone of the tooth, surrounded by corresponding portions of enamel. Between these are portions of *crusta petrosa;* and the whole circumference of the section is composed of a thick layer of the same substance.

A vertical section in the longitudinal direction exhibits the processes of bone, upon the different denticuli, running up from the fangs; a vertical layer of enamel is placed before, and another behind each of these. If the tooth is not yet worn by mastication the two layers of enamel are continuous at the part where the bone terminates in a point; and the front layer of one denticulus is continuous with the back layer of the succeeding one, at the root of the tooth; so that the enamel, ascending on the anterior, and descending on the posterior surface of each denticulus, forms a continued line through the whole tooth. *Crusta petrosa* intervenes between the ascending and descending portions of the enamel.

As the surface of the tooth is worn down in mastication, the processes of enamel, which are capable of making a resistance by their superior hardness, form prominent ridges on the grinding surface, which must adapt it excellently for bruising and comminuting any hard substance.

The grinding bases, when worn sufficiently to expose the enamel, present a very different appearance in the *Asiatic* and *African* elephants. The processes of enamel in the former species represent flattened ovals, placed across the tooth. In the latter they form a series of lozenges, which touch each other in the middle of the tooth.

It does not appear that *crusta petrosa* is an essential part in the grinders of graminivorous animals. For those of the *rhinoceros* do not possess it, although the enamel descends into their substance, and forms a cavity, which is filled with the food, &c.

Home and Blake likewise state, that it does not exist in the *hippopotamus*, where there are internal productions of enamel: but Mr. Macartney has found it in small quantity on the exterior surface of the tooth near its root.*

§ 29. Certain classes of the teeth are entirely wanting in some orders, classes, and genera of quadrupeds; as the upper front teeth in the *pecora*, the lower in the *elephant*, both in the *African rhinoceros*, and the canine in the *glires*. In other instances, the different descriptions of teeth, particularly the canine and molar, are separated by considerable intervals; this happens in the *horse* and *bear.* There is no animal in which these parts are of such equal height and such uniform arrangement as in man.

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* Mr. Corse's *Observations on the different Species of Asiatic Elephants.* Philos. Trans. 1799, part ii.

Some Observations on the Teeth of graminivorous Quadrupeds, by E. Home, Esq. Ibid. With *Delineations of the Teeth of the Elephant, Horse, Cow, Sheep, Hippopotamus, and Rhinoceros.*

Blake's *Essay on the Structure and Formation of the Teeth in Man and various Animals,* with plates.

Tenon *Sur une Méthode particulière d'etudier l'Anatomie,* in the *Mémoires de l'Institut National,* tom. i. an 6.

Cuvier, *Leçons d'Anatomie comparée,* tom. iii.

All the three kinds of teeth are found in the *quadrumana,* the *carnivora,* the *pachydermata,* (excepting the *two-horned rhinoceros* and *elephant*) the *horse,* and those *ruminating animals* which have no horns.

Cuvier states, that the teeth of an animal whose bones are found in a fossile state resemble those of man, in being arranged in a continued and unbroken series.

In the *simiæ, carnivora,* and all such as have canine longer than the other teeth, there is at least one vacancy in each jaw, for lodging the *cuspidatus* of the opposite jaw. There is a vacancy behind each canine in the *bear.*

The horned ruminating animals not only want entirely the *upper incisors,* but they are also destitute of *cuspidati,* except the *stag,* which has rudiments of these teeth; and the *musk,* (*moschus moschifer*) in which they are very long, and curved in the upper jaw.

Between the incisors and grinders of the *horse* a very large vacancy is left, in the middle of which a small *canine tooth,* termed the *tush,* is found in the male animal, but very rarely in the female.

The elephant has *grinders* and two *tusks* in the upper jaw, but the former only in the lower. The immense tusks belong properly to the male animal; as they are so small in the female, generally speaking, as not to pass the margin of the lip. (Corse, in *Phil. Trans.* 1799, part 2, p. 208.)

The *sloths* have grinding and canine teeth, without incisors. The *dolphin* and *porpoise* have small conical teeth, all of one size and shape, arranged in a continued line throughout the alveolar margin of both jaws. The *cachalot* (*physeter macrocephalus*) has these in the lower jaw only. The teeth of the *seal* are all of one form, viz. that of the canine kind, conical and pointed.

The *narwhale* has no other teeth than the two long tusks implanted in its os intermaxillare, of which one is so frequently wanting. A head, in which there are two of these tusks, is delineated by Dr. Shaw, in his Zoology, from a specimen in the Leverian Museum. These tusks are remarkable for the spirally convoluted appearance of their external surface. They are hollow internally, and probably have a constant growth like the elephant's tusks. See § 27.

§ 30. The want of satisfactory observations* prevents us from saying much on the change of the teeth, particularly in wild animals. Among the *digitata* many of the *glires,* as the marmot and rabbit, do not appear to change their teeth.* Some erroneous opinions of former times, as, for instance, that the domesticated pig changes its teeth, and that the wild animal does not, hardly require an express contradiction in the present day.† During the time of change in the *feræ,* particularly in the *dog* and *otter,* the number of their canine teeth often seems doubled, since the permanent ones cut the gum before the deciduous have fallen out. Apes, like the human subject, have no bicuspides among the deciduous teeth; but there are, instead of these, two proper molares on either side of the jaw.‡ The change of the teeth takes place in the *elephant* in a very remarkable manner.§ The new permanent tooth comes out behind the milk tooth, the vertical layers of which are gradually removed,‖ as the formation of the latter advances.¶ There is, however, perhaps no animal of this class, in which the first appearance and subsequent removal of the deciduous teeth takes place at so late a period of life as in man.

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* See the detailed description of the change of the teeth in the horse by Tenon, *Sur une Méthode particulière d'etudier l'Anatomie,* in the *Mém. de l'Institut National,* tom. ii. p. 558; and J. W. Neergaard's *Naturbeschreibung der Zahne des Pferdes mit Rücksicht auf andre Thiere.* Kopenh. 1816.

The permanent teeth are generally formed in cavities near the roots of the temporary ones, and they succeed to the vacancies left by the discharge of the latter.

A different mode of succession obtains, however, in some instances. The adult molares of the human subject are not formed near any of the temporary teeth, but in the back of the two jaws; from which situation they advance successively towards the front, in proportion as the maxillary bones are lengthened in that direction. A similar, but much more remarkable species of succession is observed in the *grinders* of the *elephant,* where it was ascertained by the labours of Mr. Corse, who has explained and illustrated the subject in a series of beautiful engravings. See *Observations on the different Species of Asiatic Elephants, and their Mode of Dentition.* Phil. Trans. 1799, part 2.

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* Le Galloi's *Expériences sur le Principe de la Vie.*

† See Home, *Phil. Trans.* 1801.

‡ In the skull of a young *orang-outang* of Borneo, which I possess through the kindness of Mr. Van Marum, there are no bicuspides.

§ The progression of dentition in the molar teeth of the elephant has been most accurately described by Cuvier, in vol. i. *Recherches sur les Ossemens Fossiles,* p. 38.

‖ See Prof. Brugman's remarks on this subject, in Van Maanen *Diss. de Absorptione Solidorum.* Lugd. Bat. 1794.

¶ I have given a drawing in the Petersburgh *Prize Dissertation on Nutrition,* 1789, 4to. of the peculiar formation of these vertical layers in the molar teeth of the *elephant,* before they appear through the gum; and particularly of the manner in which the enamel exudes from the bony substance in small processes.

We never see more than one grinder and part of another through the gum in this animal. The anterior one is gradually worn away by mastication; its fangs and alveolus are then absorbed: the posterior tooth coming forwards to supply its place. As this goes through the same stages as the preceding grinder, a third tooth, which was contained in the back of the jaw, appears through the gum, and advances in proportion as the destruction and absorption of the other proceed. The same process is repeated at least eight times, and each new grinder is larger than that which came before it. The 1st, or milk grinder, is composed of four transverse plates or denticuli, and cuts the gum soon after birth. The 2d, which has eight or nine plates, has completely appeared at the age of two years. The 3d, formed of twelve or thirteen, at six years. From the 4th to the 8th grinder, the number of plates varies from fifteen to twenty-three, which is the largest hitherto ascertained. The exact age at which each of these is completed has not yet been made out: but it appears that every new one takes at least a year more for its formation than its predecessor.

From the gradual manner in which the tooth advances, it is manifest that a small portion of it only can penetrate the gum at once. A grinder, consisting of twelve or fourteen plates, has two or three of these through the gum, whilst the others are embedded in the jaw. The formation of the tooth is complete therefore, first, at its anterior part, which is employed in mastication, while the back part is very incomplete; as the succeeding laminæ advance through the gum, their formation is successively perfected. But the posterior layers of the tooth are not employed in mastication, until the anterior ones have been worn down to the very fang, which begins to be absorbed. One of these grinders can never therefore be procured in a perfect state; for if its anterior part has not been at all worn, the back is not completely formed, and the fangs in particular are wanting, while the structure of the back of the tooth is not completed until the anterior portion has disappeared.

A similar kind of succession, but to a less extent, has been ascertained by Sir Everard Home, in the teeth of the *sus Æthiopicus.* *Observations on the Structure of the Teeth of Graminivorous Quadrupeds; particularly those of the Elephant and sus Æthiopicus.* Phil. Trans. 1799, part 2.

The researches of the same gentleman have also proved it to exist in the *wild boar* to a certain degree, and have rendered it probable that it occurred likewise in the *animal incognitum* (*mammoth*). *Observations on the Structure and Mode of Growth of the Wild Boar and Animal Incognitum.* Phil. Trans. 1801, part 2.

§ 31. The crown of the tooth is gradually worn down by the act of mastication, and receives from this cause a kind of polished surface, which is especially observable in the canine teeth of the *pig* and *hippopotamus*. The age of the *horse* is determined by the appearance of the front teeth. It has been observed in the *glires*, that when the upper or lower pair of incisors is lost, the opposite teeth grow out to a monstrous length. A similar growth takes place when these animals are confined to soft food.*

§ 32. From the head of mammalia we proceed to consider the trunk, according to its division into the three principal parts of *spine, pelvis,* and *chest*. The former of these is the most constant part of the skeleton, as it belongs to all red-blooded animals without exception, and is not found in a single white-blooded one.

§ 33. It is remarkable, that the animals of this class, at least the four-footed ones, constantly agree in the number of their cervical vertebræ. The *giraffe* or the *horse* have neither more nor fewer than the *mole* or *ant-eater*. In all there are always seven, as in the human subject. An unexpected irregularity has been discovered by Cuvier in the *three-toed sloth*;† it has nine vertebræ of the neck. In some *cetacea*, on the contrary, there are only six; and, in these animals, four or five are generally consolidated together. The *atlas* is distinguished in the *feræ* by its immense strength, and by the vast size of its transverse processes.‡

The number of cervical vertebræ is the same in the *cetacea* as in other mammalia, according to Cuvier, but some of them are anchylosed. Thus the two first are united in the *dolphin* and *porpoise;* and the six last in the genus *physeter*. *Leçons d'Anat. comp.* tom. i. p. 154.

It must be accounted a singular circumstance, that the number of cervical vertebræ should be so constantly the same in animals, whose neck differs so much in length, when the number of pieces in the other regions of the spine varies greatly in the different genera. No instance has been recorded, in which more than seven cervical vertebræ have been found in the human subject, although the number of those in the back and loins sometimes deviates from the natural standard.

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* See Morton's *Natural History of Northamptonshire*, p. 445; and Achard's *Chymico-Physical Writings*, p. 161.

† *Annales du Museum d'Histoire Naturelle*, vol. v. p. 202.

‡ The connexion which this structure has with the teeth and jaws of these rapacious animals is pointed out by Eustachius *De Dentibus*, p. 86; see also Vesling in *Severini Vipera Pythia*, Patav. 1651, p. 232.

The transverse processes of the vertebræ, which are particularly conspicuous in such carnivorous animals as have great strength in their neck, afford attachment to the large and powerful muscles by which the animal executes those strong and rapid motions of the head, which are necessary in attacking its prey, or defending itself. The *badger*, in this country, affords an excellent specimen of the structure alluded to.

The *mole* and *shrew* have no spinous processes in the neck. The vertebræ form simple rings, with considerable motion on each other. These processes are either very short, or altogether deficient in the long-necked animals, as the *horse*, *camel*, *giraffe*, &c. They would otherwise afford an obstacle to the bending of the neck backwards.

The six last vertebræ of the neck are anchylosed in the *ant-eater* and *manis.*

§ 34. The number of dorsal vertebræ is determined by that of the ribs, which will be spoken of presently. In the long-necked quadrupeds, as the *horse, giraffe, camel,* and other *pecora,* as well as in those animals whose head is very heavy, as the *elephant,* the spinous processes of the anterior dorsal vertebræ are exceedingly long, for the attachment of the great suspensory ligament of the neck *(ligamentum nuchæ).*

§ 35. The lumbar vertebræ vary much in number. The *elephant* has only three; the *camel* seven. Some *quadrumana,* as the *mandrill,* have the latter number. The *horse* has six; the *ass* five. *Mules* have generally six, but sometimes only five. Most quadrupeds have the processes of these vertebræ turned forwards; in the *ape,* they are in their ordinary position, turned upwards.* The transverse processes are remarkably large in many *ruminantia,* as also in the *hare.*

§ 36. The form and proportions of the *sacrum* are still more various. The number of its vertebræ, as they are called, varies in the different species of the same genus. Thus, in the common *bat* it consists of four pieces; in most† of the

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* Galen, in his Osteology, describes the transverse processes as having this direction; from which circumstance, as well as from his description of the *sacrum* and *os coccygis,* and several other passages, Vesalius shewed that the work was drawn up from the examination of apes, not of the human subject. See his *Epistola rationem modumque propinandi Radicis Chynæ decocti pertractans,* 1546, p. 49.

† Vesalius *De Corp. Hum. Fabrica,* p. 99.

simiæ it consists of three pieces; in the *orang-outang* of four;[*] in the *chimpansé*[†] of five. This bone is distinguished in the horse by large lateral processes at its anterior extremity; and in the *mole* by a thin sharp-edged plate, formed by the union of its spinous processes.[‡] A somewhat similar structure is found in the *armadillo,* in which animal the whole pelvis has a very anomalous formation. As the *cetacea* have no pelvis, they cannot be said to possess a sacrum.

Most of the *simiæ*, and even some which very much resemble the human subject, as the *orang-outang*, which Camper dissected, (*simia pygmæus)* have the sacrum formed of three pieces, which consequently leave only two pairs of openings for the passage of the nerves. Now, as Galen mentions these circumstances of the human sacrum in his work on the bones, it must appear very clearly that the description could not have been taken from the human subject, but was probably derived, as Vesalius supposed, from the *ape;* although Silvius and Eustachius have endeavoured to invalidate this conclusion. See Vesal. *Epist. de Rad. Chynæ;* also his great work, *De Corp. Hum. Fabrica*, p. 99.

The true orang-outang (*simia satyrus*) has a sacrum composed of five pieces. The *elephant* has also five. See Blair, *Osteogr. Elephantina*, p. 29.

§ 37. The os coccygis is prolonged, so as to form the tail of quadrupeds; and consists, therefore, in many cases, of a great number of vertebræ. In the *cercopithecus morta* there are 22; in the *cercopithecus paniscus*, 32; in the *two-toed ant-eater*, 41. When an opossum or monkey loses a portion of the tail, (an accident which has often led to confusion in determining the species) a peculiar knotty excrescence, sometimes of a carious appearance, takes place at the truncated extremity.

In *monkeys*, and even in such *simiæ* as have no tails, where the os coccygis consists at most of three pieces only, this bone is perforated by a continuation of the vertebral canal, and by openings for the transmission of nerves. This structure is ascribed by Galen to the human coccyx; and hence Vesalius has derived another argument, to shew that Galen's Osteology was not drawn from the human skeleton.

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[*] Camper states, that the sacrum of this animal has three pieces: in my specimen, however, there are manifestly four.

[†] Tyson's *Anatomy of a Pigmy*, edition of 1751, p. 89.

[‡] Its skeleton, which is altogether very curious, is accurately described by Wiedemann, in his *Archives of Zoology and Zootomy*, vol. i. p. 106. There is also a delineation of the skeleton of an armadillo, prefixed to the 8th chapter of Cheselden's *Osteography.*

The *orang-outang*, like man, has a coccyx composed of five pieces, not perforated. Tyson's *Anat. of a Pigmy*, p. 69.

Those vertebræ of the tail of mammalia, which are nearest to the sacrum, are perforated by a continuation of the canal for the medulla spinalis. The lower ones are solid. The want of a pelvis renders it impossible for us to decide the number of sacral and coccygeal vertebræ in the cetacea; but the whole number of pieces in the spine of the *dolphin* and *porpoise* is 66.

§ 38. The ossa innominata, together with the sacrum, constitute the pelvis.* There is ground for affirming, although the assertion may appear paradoxical, that no animal but man has a pelvis; for in no instance have the bones of this part that bason-like appearance, when united, which belongs to the human subject. Those *apes,* which most nearly resemble man, have the ossa innominata much elongated; and in the *elephant, horse,* &c. the length of the symphysis pubis detracts from the resemblance to a bason. In some instances, as in the *beaver* and *kangaroo,* the ossa pubis are not united by synchondrosis, but consolidated into one piece by a bony union. They are, on the contrary, separate in the *ant-eaters,* in the same manner as they are found in birds. The cavity of the pelvis is so narrow in the *mole,* that it cannot hold the organs of generation and neighbouring viscera, which lie therefore externally to the ossa pubis. In the *kangaroo,*† and other *marsupial*‡ *animals,* the superior, or rather the anterior margin of the ossa pubis, is furnished with a peculiar pair of small bones (*ossa marsupialia,* or *cornua pelvis abdominalia*) somewhat diverging from each other, and running towards the abdomen. They have an elongated and flattened form, and belong exclusively to these animals. But in the Philos. Trans. of 1802, it is stated by sir E. Home, that the *ornithorhynchus* has something of this kind. They support the abdominal pouch in the female, but are also found in the male; at least in some species. Cetaceous animals have no hind feet, nor ossa innominata, consequently no pelvis; they have, however, a pair of small bones at the lower part of the belly, which may be compared to the ossa pubis.*

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* B. G. Schreger, *Pelvis Anim. Brutorum cum Humana Comparatio.* Lips. 1787, 4to. Autenrieth and Fischer *Observationes de Pelvi Mammalium.* Tubing. 1798, 9. Plates of the pelvis of the cow, accurately measured in G. Eberhard *Over het Verlossen der Koeijen.* Amst. 1798.

† E. Home *On the Mode of Generation of the Kangaroo.* Philos. Transact. 1795.

‡ Daubenton, vol. x. tab. 51. I refer here, and in other places, where a similar quotation occurs, to the original 4to. edition of Buffon's work. It cannot, with propriety, be quoted under the name of Buffon, since it is well known that the zootomical part was furnished by Daubenton, and has been omitted in most of the subsequent editions.

§ 39. The thorax in most, if not all animals, the *marmot* perhaps excepted, of the class mammalia, is narrower, and deeper from the spine to the sternum, than in man. The less marked flexure of the ribs of animals, and the elongation of their sternum give rise to this peculiarity. The long legged animals, as the *giraffe*, and those of the stag kind, possess this keel-like form of the chest (*thorax carinatus*) in the most striking degree.

§ 40. In a very few mammalia, as some *bats* and *armadillos*, there is a pair of ribs less than in man; but in the greater number of this class there are more. Several *quadrumana* have 14 pairs; the *horse*, 18; the *ornithorhynchus*, 17; the *elephant*, 20;† the two-toed sloth, (*bradypus didactylus*) 23. The two-toed ant-eater (*myrmecophaga didactyla*) has 16 pairs, which are remarkably broad, so that the back and sides of the skeleton, as low as the ossa innominata, appear like a coat of mail.

The *ornithorhynchus paradoxus* and *histrix* have ribs of a very singular structure. Their true ribs, which are six in number, consist of two pieces of bone; a longer one joined to the spine, and a shorter connected to the sternum. These are united by means of a piece of cartilage; so as to constitute a structure approaching to that of birds. The false ribs, ten in number, terminate anteriorly in broad, flattened, oval bony plates, connected together by elastic ligaments. *Phil. Trans.* 1802, part 1, plate 3. Meckel *de ornithorhyncho paradoxo*, 1826.

§ 41. The sternum in most of the mammalia is cylindrical, and jointed. This structure occurs even in the *quadrumana* and the *bears,* whose skeletons, in other respects, resemble the human. The form of this bone is the most singular in the mole;* where its anterior extremity is prolonged into a process, almost resembling a ploughshare, lying under the cervical vertebræ, and parallel with them.

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* Rondelet *De Piscibus*, p. 461. Tyson's *Anatomy of a Porpoise*. London, 1680, p. 28.

† There are only nineteen in the skeleton of the Asiatic elephant at Cassel. Blair found the same number in the individuals of which he has given so excellent an account; and a manuscript Italian description of the elephant, which died at Florence in 1657, confirms this statement.

This process may be compared to the keel-like projection of the sternum of birds. It serves for the origin of those strong muscles of the anterior extremity, which assist the animal in digging its way under ground.

§ 42. We proceed to speak of the extremities, as they are called, which, although they vary considerably in the class of mammalia, may, on the whole, be compared to those of man in their chief component parts, and in the mode in which these are connected together.

Some passages of Aristotle† have given rise to the singular mistake of supposing that the elbow and knee of quadrupeds are bent in a direction exactly opposite to that of the human subject. The error must have arisen from the shortness of the thigh and arm bones, which lie close to the trunk, particularly in long-legged quadrupeds, and do not project freely as in man, the *quadrumana,* the *bear,* the *elephant,* &c. Hence the different bones of the extremities in these animals have been compared to such parts in the human body as do not in reality correspond with them.‡

We may assert, as a general observation, that the four component parts of the upper extremity, viz. the shoulder, arm, fore-arm, and hand, can be clearly shown to exist in the anterior extremities of all mammalia; however dissimilar they may appear to each other on a superficial inspection, and however widely they may seem to deviate from the human structure.

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* It is hardly necessary to remind the readers, that the terms *anterior, posterior, superior,* and *inferior,* are always applied to quadrupeds with reference to the horizontal position of their body. Consequently the term *anterior* designates those parts, which, in the erect position of the human body, are *superior;* and so of the others.

† Aristot. *Hist. Anim.* 2. 1; and *De Incessu Anim.* c. 11, Plin. ii. 102.

‡ See on this subject Fab. ab Aquapend. *De motu locali Animalium secundum totum,* in his *Oper. Anat.* p. 343, Albinus's ed.; and Barthez *Des Mouvemens Progressifs de l'Homme,* in the *Journal des Sçavans,* January, 1783, p. 34, of the Paris 4to. edit.

Whenever an animal of one class resembles those of a different order in the form and use of any part, we may be assured that this resemblance is only in externals; and that it does not affect the number and arrangement of the bones. Thus the *bat* has a kind of wings, but an attentive examination will prove, that these are really hands, with the phalanges of the fingers elongated. The *dolphin, porpoise,* and other *cetacea*, seem to possess fins, consisting of a single piece. But we find, under the integuments of the fin-like members, all the bones of an anterior extremity, flattened in their form, and hardly susceptible of any motion on each other. We can recognize very clearly the scapula, humerus, bones of the fore-arm, and a hand consisting of five fingers; the same parts, in short, which form the anterior extremity of other mammalia. See Tyson's *Anatomy of a Porpoise,* fig. 10 and 11: also Blasii *Anatomia Animalium,* tab. 51, fig. 3, 4.

The fore-feet of the *sea-otter, seal, walrus,* and *manati,* form the connecting link between the anterior extremities of other mammalia, and the pectoral fins of the whale kind. The bones are so covered and connected by integuments, as to constitute a part, adapted for the purposes of swimming; but they are much more developed than in the latter animals, and have free motion on each other.

The cold-blooded quadrupeds bear great analogy in the four component parts, and in the general structure of their anterior extremities, to the warm-blooded ones. See Caldesi's *Observations on the Turtle,* tab. 3, fig. 1, 4, 5.

The bones of the wing of birds have a considerable and unexpected resemblance to those of the fore-feet of the mammalia; and the fin-like anterior member of the penguin contains, within the integuments, the same bones as the wings of other birds.

§ 43. The clavicle has been said, even by some excellent modern zoologists, to be confined to Linnæus's order *primates* (in which he includes *man,* the *quadrumanous animals,* and *bats*); but it exists in a great number of mammalia* besides these; particularly in such quadrupeds as make much use of their fore-feet, either for holding objects, as the *squirrel* and *beaver;* or for digging, as the *mole;* or for raking the ground, as the *ant-eater* and *hedgehog;*† or for climbing, as the *sloth.* Many other animals have, in its place, an analogous small bone, merely connected to the muscles,* and called by Vicq d'Azyr *os claviculare* to distinguish it from the more perfect clavicles. This is the case with most of the *feræ,*† and some *glires.* Lastly, the form and relative magnitude of the true articulated clavicles are subject to great variety. They are excessively long in the *bat.* Those of the *orang-outang* have the greatest resemblance to the human subject. In the *two-toed anteater* their form is that of a rib: their figure is most anomalous in the *mole,*‡ where they are nearly cubical. They are entirely wanting in the long-legged quadrupeds with keel-shaped chest; viz. the *pecora* and *solidungula;* as well as in the *cetacea.*

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* J. G. Haase, *Comparatio clavic. Anim. Brut. cum Humanis.* Lips. 1766, 4to. Vicq d'Azyr *Sur les Clavicules* and *Les Os Clavic.* in *Mém. de l'Acad. des Sciences,* 1785.

† The use of the clavicles in some of the animals here enumerated is well pointed out by Fab. Hildanus, in his *Short Description of the Excellence of Anatomy.* Bern. 1624-8, p. 219.

The clavicle supports the anterior extremity, and maintains the shoulder at its proper distance from the front of the trunk. It exists, therefore, in all such animals as make much use of these members, whether for the purpose of climbing, digging, swimming, or flying. It does not exist, on the contrary, in such as use their fore-feet merely for the purpose of progression; since these limbs must be brought more forward on the chest, that they may support that part, by being placed perpendicularly under it. In the genera, which hold an intermediate rank between these, which do not possess so much power in the fore-feet as the first division of animals, and are not so limited in their employment as the second, the *clavicular bones,* or imperfect clavicles, exist.

§ 44. The scapula exists in all red-blooded animals, which have anterior extremities, or similar organs of motion: consequently in both classes of warm-blooded animals without exception. The form of this bone varies much even in mammalia; and particularly the relation which its three sides bear to each other. This depends on the position of the bone, which is determined by the general form of the chest. The margin, which is turned towards the spine, is the shortest in most of the proper quadrupeds, particularly the long-legged ones with narrow chest; in which the scapulæ lie on the sides of the chest. In some, as the *elephant,* the *chiroptera,* most of the

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* Hence, Serae compares it to the sesamoid bones. See his *Opusc. de Physico Argumento.* Naples, 1766, 4to. p. 84.

† Pallas *Spicilegia Zoologica,* fascic. 14, p. 41.

‡ On this point, and the whole subject of the osteology of the mole, see Jacob's *Anatome talpæ Europeæ.* Jen. 1816.

quadrumana, and especially in man, this margin is the longest. The scapula of the *mole** has a completely anomalous figure, almost resembling a cylindrical bone. The coracoid process and acromion, the two chief projections of this bone, are strongest in such animals as have two long clavicles; which might have been inferred *à priori.*

§ 45. The remarkable varieties of the anterior extremities, properly so called, may be most conveniently considered according to the orders and genera of animals of this class. The *bat* and the *mole* present the widest deviations from the ordinary formation of these parts. The radius is deficient in the forearm of the former; or at most there is only a slender sharp-pointed rudiment† of this bone; their thumb is short, and furnished with a hook-like nail: the phalanges of the four fingers, between which the membrane of the wing is expanded, are on the contrary extremely long and thin, almost like the spines of a fish, and have no nails.‡ The *flying squirrel* has a peculiar sharp-pointed bone at the outer edge of its carpus, connected to that part by means of two small round bones, which enables it to spring from great heights. The form of the os humeri in the mole is altogether unparalleled; it is thin in the middle, and surprisingly expanded at either extremity. The shovel-like paw of this animal is provided with a peculiar *falciform bone,* lying at the end of the radius. The phalanges of the fingers are furnished with numerous processes, and have moreover sesamoid bones; all which, by increasing the angle of insertion of the tendons, contributes to facilitate muscular motion. The animals with divided claws and hoofs have some peculiarities in the *metacarpus* and *metatarsus.* In the *pig* these parts consist of four cylindrical bones. In the *seal* the large bones of the anterior extremities are not cylindrical, but flattened; by which structure they serve better the purpose of rudders. In the *pecora*, before birth, there are two lying close together; but they are afterwards formed into one by the absorption of the septum.* The *horse* has a single bone (*gamba*, Vegetius; in French, *le canon;* in English, the *cannon bone*, or *shank bone*), with a pair of much shorter and immoveable ones, attached to its posterior and lateral parts, and firmly united to it, (*les poinçons* or *os epineux*, *styloid* or *splint bones*). The main bone only is articulated to the *pastern*, which may be compared to the first phalanx of the human finger; as the *coffin bone* resembles in some degree the third phalanx, which supports the nail.† This last phalanx is very various in its form, according to corresponding variations in its horny coverings, which may consist of a flat nail or claw, or hoof, &c.

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* On the wonderful structure of the scapula, and its connexion with the anomalous clavicle and sternum of the *ornithorhynchus,* see Home, *Phil. Trans.* De Blainville, *Diss. sur la Place que la Famille des Ornithorynques et des Echidnés doit occuper dans les Séries Naturelles.* Paris, 1812; and Jaffé *De Ornithorhyncho Paradoxo.* Berol. 1823.

† Weygand, Suppl. IV. to the Breslau Collection, p. 55.

‡ Lion. Da Vinci endeavours to prove from the structure and mechanism of the bat, and not of birds, in what manner men might also be able to fly. Vid. *Amoretti Vita di L. D. V.* p. 145.

The humerus becomes shorter, in proportion as the metacarpus is elongated; so that in animals which have what is called a cannon bone, the os humeri hardly extends beyond the trunk. Hence the mistakes, which are made in common language, by calling the *carpus* of the horse his fore-knee, &c.

The radius forms the chief bone of the fore-arm in the mammalia, generally speaking; the ulna is a small slender bone, terminating short of the wrist in a point, and often consolidated with the radius, as in the *horse* and *ruminating animals*. A few genera, which have great and free use of their anterior extremity, have the power of pronation and supination. But this power diminishes, as the fore-feet are used more for the purpose of supporting the body in standing, and in progression. In this case, indeed, the extremity may be said to be constantly in the prone position, as the back of the carpus and toes is turned forwards.

The lower end of the ulna is larger than that of the radius in the elephant; but this circumstance occurs in no other instance.

The radius and ulna exist in the *seal*, *manati*, and *whales*, but in a flattened form.

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* J. B. Covolo *De Metamorphosi duorum Ossium Pedis in Quadrupedibus aliquot.* Bonon. 1765, 4to.; and Fougeroux in the *Mém. de l'Acad. des Sc.* 1772, p. 520.

† The effect of bad shoeing in disfiguring the natural texture of the hoof of the horse, and the structure of the hoof itself, are well explained by Bracy Clarke in his *Series of original Experiments on the Foot of the living Horse.* Lond. 1809.

Several genera of mammalia possess a hand; but it is much less complete, and consequently less useful than that of the human subject, which well deserves the name bestowed on it by Aristotle, of the *organ of all organs.* The great superiority of that most perfect instrument, the human hand, arises from the size and strength of the thumb, which can be brought into a state of opposition to the fingers, and is hence of the greatest use in grasping spherical bodies, in taking up any object in the hand, in giving us a firm hold on whatever we seize; in short, in a thousand offices, which occur every moment of our lives, and which either could not be accomplished at all, if the thumb were absent, or would require the concurrence of both hands, instead of being done by one only. Hence it has been justly described by Albinus as a second hand "*manus parva majori adjutrix,*" *De Sceleto*, p. 465.

All the *simiæ* possess hands: but even in those, which may be most justly styled *anthropomorphous*, the thumb is small, short, and weak; and the other fingers elongated and slender. In others, as some of the *cercopitheci,* there is no thumb, or at least it is concealed under the integuments; but these animals have a kind of fore-paw, which is of some use in seizing and carrying their food to the mouth, in climbing, &c. like that of the *squirrel.* The genus *lemur* has also a separate thumb. Other animals, which have fingers sufficiently long and moveable for seizing and grasping objects, are obliged, by the want of a separate thumb, to hold them by means of the two fore-paws; as the *squirrel, rat, opossum,* &c. Those, which are moreover obliged to rest their body on the fore-feet, as the *dog* and *cat,* can only hold objects by fixing them between the paw and the ground. Lastly, such as have the fingers united by the integuments, or enclosed in hoofs, lose all power of prehension.

The *simiæ* in general have nine bones in the carpus. Riolani *Anthropographia* and *Osteolog.* p. 908. Paris, 1626; but there are only eight in the *orang-outang*, according to Tyson. There are five carpal bones in the fin of the whale, of a flattened form, and hexagonal.

The metacarpus is elongated in those animals, where the toe only touches the ground in standing or walking; and constitutes the part, which is commonly called the fore-leg; as the carpus is termed the knee.

The number of metacarpal bones is the same with that of the fingers or fore-toes: except in the ruminating animals. Even in these, as the author observes, there are two distinct metacarpal bones, lying close together before birth: the opposed surfaces first become thinner, then are perforated by several openings, and at last disappear; so that the adult animal has a single cannon bone, possessing a common medullary cavity internally, and marked on the outside with a slight groove at the place of the original separation. There is therefore but one metacarpal bone in the adult for the two toes. The structure of the metatarsus is the same.

In the *horse* on the contrary, if we allow the *splint bones* to belong to the metacarpus, there will be three to a single toe. Daubenton considers the common bone of this animal as supplying the place of the three metacarpal bones of man; he compares the outer splint bone to the metacarpal bone of the little finger, and the inner to that of the thumb. Stubbs views the cannon as the metacarpal of the middle and ring fingers; and the inner-splint as that of the fore-finger. Buffon, *Hist. Naturelle,* 4to. ed. p. 362, vol. iv. Stubbs's *Anatomy of the Horse.*

The single finger or fore-toe of the horse is composed of the usual three phalanges; the first, which is articulated to the cannon, is called the *pastern;* the 2nd is the *coronet;* and the 3rd, the *os basis* or *coffin bone;* on which the hoof rests. There are also two sesamoid bones at the back of the pastern joint; and an additional part, called the *shuttle-bone,* connected to the coffin.

In those animals which have five toes, as the *carnivora,* &c., that which lies on the radial side of the extremity, and is therefore analogous to the thumb, is parallel with the others; and the animal consequently has not the power of grasping any object. The last phalanx in these supports the nail of the animal; and sends a process into its cavity. These parts are so connected that the nail is naturally turned upwards, and not towards the ground; so that its point is not injured in the motions of the animal. The phalanx must be bent in order to point the nail forwards or downwards.

The order of *rodentia* have generally five toes; that which corresponds to the thumb being the shortest.

The *elephant* has five complete toes; but they are almost concealed by the thick skin.

The *pig* has four toes; two larger ones, which touch the ground; and two smaller behind these, which do not reach so far. There is also a bone, which seems to be the rudiment of a thumb.

The phalanges of the *cetacea* are flattened, not moveable, and joined together in the fin.

§ 46. I have something to say respecting the posterior extremities. The femur of most quadrupeds is much shorter than the tibia, and hence it hardly projects from the abdomen. In some few, as the *bear,* the femur is longer; this is also the ease in some *apes,* viz. the *orang-outang,* in which, as in several other apes and baboons, the bones of the arm and forearm are surprisingly longer than those of the thigh and leg. Some, as the *elephant,* have no ligamentum teres; consequently there is no impression made on the head of the thighbone, while it is found in others, as the *rhinoceros.* The *pecora* want the fibula almost universally. The peculiar form of the *astragalus,* (*talus*) in the same order is generally known from the use which the ancients* made of the bone in their celebrated game. In some quadrumana, as the *orang-outang*, the two posterior phalanges of their toes are remarkably curved in their shape; a structure which enables them to hold the branches of trees more firmly, and is in the same degree unfavourable to the action of progression in an erect position. Cetaceous animals have no bones in their tail fins, but they have a bony compages in their thoracic fins, which completely resembles the front extremities of the seal. This is also the case with the manati, whose front extremities were formerly taken for Sirens' hands.†

The length of the femur depends on that of the metatarsus; and it bears an inverse ratio to the length of that part.

Hence it is very short in the *horse*, *cow*, &c. where the same mistakes are commonly committed in naming the parts, as in the anterior extremity.

The proportions of the thigh and leg vary in different animals. The latter part exceeds the former in the human subject; and the same remark may be made respecting the arm and fore-arm. These parts are nearly of the same length in the *orang-outang*. Some persons have affirmed that the negro forms a connecting link between the European and the orang-outang in these respects. (White *on the regular Gradation in Man and Animals*, &c.) In some other simiæ the leg and fore-arm exceed the thigh and arm. In other animals, although there are some varieties, the leg is generally longer than the thigh.

The femur of the mammalia is not arched as in the human subject: it possesses scarcely any neck; and the great trochanter ascends beyond the head of the bone.

The fibula is behind the tibia in many animals, as the *dog* and the *rodentia*. It is consolidated to that bone at its lower end in the *mole* and *rat*. It only exists as a small styloid bone in the *horse*, and becomes anchylosed to the tibia in an old animal.

The structure of the metatarsus in the ruminating animals, and the *horse*, is the same with that of the metacarpus.

The tarsus of the *horse* is composed of six bones; and is the part known in common language by the name of the *hock*.

Animals of the genus *simia* and *lemur*, instead of having a great toe placed parallel with the others, are furnished with a real thumb, i. e.

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* Aristotle, *Hist. Anim.* l. 2, c. 1; and *De partibus Animal.* l. 10, c. 4. For the various appellations of this well known bone in most of the European and Oriental languages, and for its form in different animals, see Th. Hyde, *Historia Talorum*, in the 2nd vol. of his *Syntagma Dissertationum*. Oxon. 1767, 4to. p. 310.

† Bartholin. *Hist. Anat.* cent. 2, p. 188.

a part capable of being opposed to the other toes. Hence these animals can neither be called *biped,* nor *quadruped,* but are really *quadrumanous* or *four-handed.* They are not destined to go on either two or four extremities, but to live in trees, since their four prehensile members enable them to climb with the greatest facility ; so that Cuvier has denominated them " *les grimpeurs par excellence.*" (Leçons d'Anat. comp. vol. i. p. 493.) The prehensile tail of several species is a further assistance in this way of life. The *opossum,* and others of the genus *didelphis,* have a similar structure with the *quadrumana ;* and it answers the same purpose. Here however there is a separate thumb on the posterior extremity only, whence Cuvier calls them *pedimanes.*

Man is the only animal, in which the whole surface of the foot rests on the ground ; and this circumstance arises from the erect stature which belongs exclusively to him. In the *quadrumana,* in the *bear, hedgehog,* and *shrew,* (which are called by Cuvier *plantigrades*) the os calcis does not touch the ground.

The heel of a species of bear belonging to this country, viz. the *badger,* (*ursus meles*) is covered with a long fur, which proves that this part cannot rest on the ground ; although the structure both of the bones and muscles of the lower extremity of this animal, approaches considerably to that of man. The same fact is stated of the bear itself, properly so called, in the *Description anatomique d'un Caméléon, d'un Castor, d'un Ours,* &c. Paris, 1669, 4to. ; the plate is contained in Blasius's *Collection,* tab. 32.

In other animals the body is supported upon the phalanges of the toes, as in the *dog* and *cat* ; in the *horse* and *ruminating animals* no part touches the ground but the last phalanx. Here the elongation of the metatarsus removes the os calcis to such a distance from the toe, that it is placed midway between the trunk and hoof.

CHAPTER III.

ON THE SKELETON OF BIRDS.

§ 47. The skeleton* of birds has considerable uniformity in the whole class; and it exhibits, when compared with the variously formed skeletons of mammalia, a very great and unexpected similarity to that of the human subject.†

§ 48. The skull of birds is distinguished by this peculiarity, that the proper bones of the cranium,‡ at least in the adult animal, are not joined by sutures, but are consolidated as it were into a single piece.

A peculiarity, which seems to be confined to the *cormorants*, must be here mentioned. There is a small sabre-shaped bone at the back of its vertex, which is supposed to serve as a lever in throwing back the head, when the animal tosses the fishes, which it has taken, into the air, and catches them in its open mouth. But the same motion is performed by some other piscivorous birds, who are unprovided with this particular bone.§

Birds have, without exception, only a single condyle, placed at the anterior margin of the great occipital foramen.

There is also, in the whole class, a bone of a somewhat square figure, (called by the French *os carré*)[*] by which the lower jaw is articulated with the cranium on both sides, in the neighbourhood of the ear.

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* See Nitzch, *Osteografische Beyt. zur N. G. der Vögel.* Leips. 1811; and Tiedemann's *Zoologie*, tom. ii. and iii.

† As that excellent naturalist Belon has already shewn in his *Histoire de la Nature des Oiseaux avec leurs Naifs Portraits retirez du Naturel.* Paris, 1555, fol. p. 40.

‡ Consult on this subject Vinc. Malacarne, *Of the Parts relating to the Brain of Birds,* in the *Memoirs of the Italian Society,* tom. i. and ii.; and Geoff. St. Hilaire, in the *Annal. du Museum,* tom. iii. cah. 58.

§ The whole skeleton of the *cormorant* is represented by Coiter in the 4th of his excellent plates, which are attached to his edition of the *Lectiones Fallopii de partibus similaribus,* &c. Norib. 1575, folio.

The ossa unguis are common to birds with mammalia, but appear to be more general in the former than in the latter: they are of considerable size, and must be distinguished from the superciliary[†] bones which probably belong to the *accipitres,* or predacious birds, only.

The cranial bones of birds form, as might be expected, a link between those of the amphibia and the mammalia. The number of the separate bones on the sides and the base of the cranium is greater in birds than in the mammalia. The principal difference between the head of birds and that of man and other mammalia is, that the cranial bones of the former are less developed, whereas, on the contrary, they are more completely separated and fully developed in the latter. Hence all the bones of the skull in birds unite in one piece, and lose their individuality. The large bones of the face and of the beak project forward under the small skull. This enlargement of the face is effected by several bones, which in man and mammalia only exist on parts of the cranial bones; for instance, the lesser alæ of the sphenoid bones in birds are separated from the skull, and become facial or beak bones.

The single condyle placed at the anterior margin of the great occipital foramen, gives the head a great freedom of motion, particularly in the horizontal direction. It enables the bird to place its bill between the wings, when asleep; a situation, in which none of the mammalia can bring the snout.

The *os quadratum* has a true articulation both with the lower mandible and with the cranium. Another small bone is connected to it, and rests by its opposite end against the palate. Hence, when the square bone is brought forwards, which it is by the depression of the lower mandible, and in a greater degree by some particular muscles, the second bone presses against the palate, so as to elevate the upper jaw.

§ 49. The jaws are wholly destitute of teeth.[‡] The superior maxilla, which is completely immoveable in mammalia, has, with a few exceptions, more or less motion in birds.* It either constitutes a particular bone, distinct from the rest of the cranium, to which it is articulated, as in the *psittaci*† (birds of the parrot kind); or it is connected into one piece with the cranium, by means of yielding and elastic bony plates; as is the case with birds in general. It is quite immoveable in very few instances; as in the *rhinoceros bird* (at least in that which I possess in my collection).

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[*] Herissant has given it this name in the *Mém. de l'Acad. des Sc.* 1748. But Coiter has pointed it out in the work before quoted.

[†] See Merrem's *Observations relating to Zoology,* p. 120.

[‡] In the upper jaw of some birds, modern zootomists have detected a rudiment of the maxillary bone. See Fischer's *Monograph,* p. 115; and Geoff. St. Hilaire, in the *Annales du Museum,* tom. x. p. 347.

Respecting the question which has been recently agitated, whether in the flamingo the upper jaw only is moveable, and on the contrary the lower one perfectly immoveable; I can state that in the skull of this bird which I have now before me, this is in no way the case.‡

The bill of birds may be considered, in some degree, as supplying the place of teeth. It consists of a horny fibrous matter, similar to that of the nail, or of proper horns; and is moulded to the shape of the bones, which constitute the two mandibles, being formed by a soft vascular substance, covering these bones. Its form and structure are as intimately connected with the habits and general character of the animal, as those of the teeth are in the mammalia.

The bill is of extraordinary hardness in birds which tear their prey, as in *eagles*, or in those which have to bruise hard fruits, as *parrots*, or in those which penetrate the bark of trees, as the *woodpecker*, *nuthatch*, &c.

This hardness is gradually diminished in those which take less solid nourishment, or which swallow their food whole; and the bill becomes a portion of nearly soft skin in those which require a sense of feeling in the part to enable them to obtain their food in mud, or water, as in *ducks*, *woodcocks*, *snipes*, &c.

Many birds, especially birds of prey and the gallinaceous tribe, have the base of the bill covered with a soft skin called *cire*, the use of which is not known.

As the bill of birds is at the same time the organ of prehension and manducation, it has an important influence on their character and habits. *Cæteris paribus*, there is greater strength in a short than in a long bill, in a thick and solid, than in a thin or flexible one;

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* Herissant *Sur les Mouvemens du Bec des Oiseaux*, in the *Mém. de l'Acad. des Sciences*, 1748, p. 345, with excellent plates.

† Labillardière says also of the upper mandible of the *pelicanus varius*, "*Cette mandibule est mobile, comme celle des perroquets.*" *Relation du Voyage*, &c. i. p. 210.

‡ Buffon, *Hist. Nat. des Oiseaux*, vol. xvi. p. 300, ed. in 12mo.

but the general form produces infinite variety in the application of force.

A bill hooked at the end with sharp edges characterises birds of prey, whether those which prey on the smaller birds and quadrupeds, or those which prey on fishes, as the *albatross*, the *petrel*, &c. The former have a shorter beak, and proportionally greater strength. A tooth-like process on each side adds greatly to the strength of such a bill; hence the birds which are provided with these processes are considered more noble and courageous than the birds of prey which want them. The shrike, which possesses them, scarcely yields in courage to the common birds of prey, notwithstanding its small size, and the weakness of its wings and feet. When the hooked bill tapers towards the end, it approximates to the knife-shaped bill, which is peculiar to semi-predacious birds, birds of carrion, *crows*, *pies*, &c. The knife-shaped bill indicates a character similar to that of aquatic birds, such as the *grebe*, *gull*, &c.

Another species of strong sharp-edged bill, of an elongated shape, but without a hook, serves to cut and break, but not to tear. This is the form of the bill in birds which live upon animals which make resistance in the water, as reptiles, fishes, &c. Some of these bills are quite straight, as in the *heron*, the *stork;* some are curved towards the bottom, as in the *tantalus*, or towards the top, as in the *jabiru*.

Some sharp-edged bills have their sides approximating, like the blade of a knife to its handle, and can only serve to seize small substances; of this description is the bill of the *penguin*, the *puffin* (where it has the further peculiarity of being as deep as it is long) and the *cut-water*, in which another singular circumstance is observed, namely, that the upper mandible is shorter than the lower, so that the bird can only seize substances by pushing them before it, as it skims along the water. Lastly, there are some sharp-edged bills, which are flattened horizontally; they serve to seize fishes, reptiles, and other large objects. The *boat-bill* has a bill of this description, which is also furnished with tooth-like processes. Some *fly-catchers* and *green todies* have a similar structure on a minute scale.

Of the bills, of which the edges are not cutting, some are flattened horizontally. When they are long and strong, they serve for swallowing prey of large dimensions, but which makes little resistance. When they are long and weak, as in the *spoon-bill*, in which the flattened extremity of this part gives the name to the bird, they serve only to imbibe small objects in the mud or water.

The bills of *ducks*, which are in some degree flattened, the more conical ones of *geese* and *swans*, and that of the *flamingo*, of which the upper mandible crosses the lower, have all transverse laminæ ranged along their edges, which, when the bird has seized any thing in the water, give passage to the superfluous fluid. Thus all these birds are aquatic. In the *goosanders*, which in other respects partake very much of the nature of ducks, these laminæ become small, conical, tooth-like processes, which are well adapted for holding fish, of which the *goosanders* destroy great numbers. Wholly different from these are the long, thin, soft bills, peculiar to birds which derive their food from animals in mud or stagnant waters. They are straight in the *snipe*, hooked towards the end in the *curlew*, and towards the top in the *avocette*.

The bills of the *toucan* and the *calao* are remarkable for their extraordinary size, which is sometimes equal to that of the whole bird. The osseous substance of these bills is of an extremely light cellular texture, without which they would be incapable of maintaining an equilibrium in their flight. The horn which covers them is so fine as to become irregularly indented on its edges, by the use which the bird makes of it. In addition to their enormous bills, the *calaos* have prominences upon them of the same substance, and of various forms, the use of which is not known. The *calao rhinoceros* is the most remarkable in this respect, as it appears to have two enormous bills, one over the other.

The *wood-peckers* have a long, strong, prismatic bill, compressed at the end, which enables them to penetrate the bark of trees. That of the *king-fisher* is nearly similar; but being much longer in proportion to the size of the bird, it cannot serve the same purposes; besides, the tongue, which is of great importance in determining the use of the bill, is altogether different.

The short, conical, arched bill of the *gallinæ* serves only to take up grain and similar substances, which they swallow so quickly that small pebbles are frequently united with their food. These birds, in an unconfined state, feed on insects as well as grain; indeed the young ones, in many species, live for some time exclusively on insects.

The bills of the smaller birds (*passeres*) present all the varieties of the conical form, from the broad-based cone of the *hawfinch* to the thread-like cone of the *humming-bird*. Such of them as have a short strong bill live on grain; those with a long, thin bill, on insects. Where this weak bill is short, flat, opening very anteriorly, as in *martins* and *swallows*, the bird seizes flies and butterflies in the air; if it be long and curved, possessing some strength, as in the *hoopoe*, it grubs up worms for its food. The tubulated tongue of the *humming-bird* is capable of being elongated so as to enable it to suck up honey from the calices of flowers.

Of all bills the most extraordinary is certainly that of the *cross-bill*, in which the two mandibles cross each other at a considerable angle, for this formation seems to be directly opposed to the natural purposes of a bill. The bird, however, contrives to pick out the seeds from the cones of the fir, and it is limited to that species of nourishment.

§ 50. The proportionate magnitude of the bones of the cranium and jaws varies much in this class. The former are large in the *owl;* the latter are of vast magnitude in the *rhinoceros bird.* A most remarkable sexual difference appears in the skull of the *crested hens:* in these the frontal portion of the cranium is dilated into an immense cavity, on which the crest of feathers is placed. This degeneracy of the formative impulse, which is propagated to the offspring, is quite unparalleled in the whole animal kingdom.[*] I have lately examined several heads of such hens in a fresh state, and have found that this peculiar dilatation of the cranium is filled by the hemispheres of the cerebrum; and it is separated from the posterior part which holds the cerebellum, as in the common hen, by an intermediate contracted portion.

§ 51. One of the peculiar characteristic differences of the cranium of birds when compared to each other,[†] consists in the mode of separation of the orbits, which are of great size in the whole class. In some they are separated by a membranous partition only; in others by a more or less complete bony septum. The relation which the nasal and palatine openings bear to the upper jaw varies much, even in the different species of the same genus. They are small in the *stork*, and on the contrary, so large in the *crane*, that the longest portion of the jaw appears to consist merely of three thin portions of bone, placed far apart from each other, and converging towards the point of the bill.

§ 52. The want of motion in the back of birds, (their dorsal vertebræ have the spinous, and even the transverse processes, often anchylosed) is compensated by a larger number, and greater mobility of the cervical vertebræ; of which, to quote a few instances, the *raven* has 12, the *cock* 13, the *ostrich* 18, the *stork* 19, and the *swan* 23.

§ 53. The trunk of birds has fewer cartilaginous parts than the corresponding division of the skeleton in mammalia. That part of the spine which belongs to the trunk is short and rigid, and has no true lumbar vertebræ. Neither has any bird an os coccygis prolonged into a true jointed tail. In the *gallus ecaudatus*, in which the rump has been lost by degeneration, there is nothing more to be seen of the coccyx than an unshapely knotty process.

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[*] See Pallas, fasc. 4, *Act. Acad. Petropolit.* 1780, part 2, p. 97.

[†] See J. T. Klein, *Stemmata Avium.* Lips. 1759, 4to.

The number of cervical vertebræ in birds varies from ten to twenty-three; those of the back from seven to eleven. From hence to the tail they are consolidated into one piece with the os innominatum. The tail has from seven to nine pieces.

The length of the neck increases generally in proportion to that of the legs; but in aquatic birds in a much greater proportion, since they have to seek their food below the surface of the water on which they swim.

The cervical vertebræ are not articulated by plane surfaces, but by cylindrical eminences, which admit a more extensive motion, as they constitute real joints, instead of synchondroses. Four or five of the upper pieces only bend forwards, while the lower ones are confined to flexion backwards. Hence the neck of a bird acquires that double bend, which makes it resemble the letter S. It is by rendering the two curvatures more convex, or more straight, that the neck is shortened or elongated. The great mobility of the neck enables birds to touch every point of their own body with the bill, and thus to supply the want of the prehensile faculty of the superior extremity. The *atlas* has the form of a small ring, which articulates with the head by only one surface. In proportion to the mobility of the neck of birds is the fixed state of the dorsal vertebræ, which are connected together by strong ligaments. The greater part of their spinous processes are consolidated into a single piece, which runs like a ridge along the whole back. The transverse processes terminate in two points, one directed anteriorly, the other posteriorly; they meet those of the two other classes of vertebræ, sometimes anchylosing with them, as the spinous processes do with each other. This structure is necessary to give steadiness to the trunk in the violent motions required by the action of flying. Accordingly birds which do not fly, as the *ostrich* and the *cassowary*, have a moveable spinal column.

The vertebræ of the tail are most numerous in those birds which move it with the greatest force, as the *magpie* and the *swallow*. They have inferior as well as superior spinous processes, and the transverse processes are long. The last is the largest, and has the shape of a ploughshare, or flattened disk. The *cassowary*, which has no visible tail, has this last bone; in the *peacock*, it has the shape of an oval plate, situated horizontally.

§ 54. The pelvis of birds is chiefly formed by a broad and simple os innominatum; the lateral portions of which are of different figures in the several genera; but, instead of uniting below to constitute a symphisis pubis, they are quite distant from each other. The *ostrich* alone forms a remarkable exception to this rule, inasmuch as its pelvis, like that of most quadrupeds, is closed below by a complete junction of the ossa pubis.

The pelvis of birds consists of the same bones as that of man. The length and breadth of the pelvis vary in different classes of birds ; it is broadest and most developed posteriorly in the gallinaceous birds, which seldom fly and generally go erect. The pelvis is small and short in birds of prey ; that of the *passeres, pici*, and *levirostres* holds a middle place between the pelves of the *gallinaceous birds* and the *birds of prey.* In the *anseres,* (*swimming birds*) the pelvis is very much elongated. It is particularly small and laterally compressed in some of the *grallæ,* so that the ossa innominata and sacrum form a kind of keel. In the *ostrich* and *cassowary* the pelvis is closed anteriorly, and resembles that of mammalia.

§ 55. Birds have fewer ribs than mammalia ; the number, I believe, never exceeds ten pairs. The false ribs, i. e. those which do not reach to the sternum, are directed forward ; the true ones are joined to the margin of the sternum by means of small intermediate bones. The middle pairs are distinguished by a peculiar flat process, which is directed upwards and backwards.

§ 56. The sternum of these animals is prolonged below into a vertical process, (*crista*) for the attachment of the strong pectoral muscles. In the male wild swan (*anas cygnus*) and in some species of the genus *ardea*, as the *crane*, this part forms a peculiar cavity for the reception of a considerable portion of the trachea. The crista is entirely wanting in the *ostrich* and *cassowary ;* where the sternum presents a plane and uniformly arched surface. This peculiarity of structure is accounted for by observing, that these birds have not the power of flying. The wings, which are very small, assist in balancing the body as they run.

§ 57. The wings are connected to the trunk by means of three remarkable bones.* The clavicles, which are always strong, constitute straight cylindrical bones. Their anterior extremities are connected to the sternum by means of a bone peculiar to birds ; viz. the *fork-like bone*, or, as it is more commonly termed, the *merry thought.* (*Furcula,* or *os jugale,* in Latin, *la lunette*, or *fourchette*, in French.) The *ostrich* and *cassowary* have indeed no separate *furcula;* but on either side of the front of the chest an elongated flat bone, consisting of a rudiment of the *furcula,* with the clavicle and scapula consolidated into one piece.*

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* For an account of several differences in their structure, see Vicq d'Azyr in his *Mémoires pour servir à l'Anatomie des Oiseaux,* in the *Mém. de l'Acad. des Sc.* 1772, p. 626.

The point of the fork-like bone is joined to the most prominent part of the keel of the sternum; and the extremities of its two branches are tied to the humeral end of the clavicles and the front of the scapulæ, just where these bones join each other, and are articulated with the humerus. Hence it serves to keep the wings apart in the rapid motions of flying. "As a general observation it may be stated, that the *fork* is strong and elastic, and its branches wide, arched, and carried forwards upon the body, in proportion as the bird possesses strength and rapidity of flight; and accordingly the *struthious birds,* (*ostrich* and *cassowary*) which are incapable of this mode of progression, have the fork very imperfectly formed. The two branches are very short, and never united in the *African ostrich*, but are anchylosed with the scapula and clavicle. The *cassowary* has merely two little processes from the side of the clavicle, which are the rudiments of the branches of the fork. In the *New Holland ostrich* there are two very small thin bones, which are attached to the anterior edge of the dorsal end of the clavicles by ligament; they are directed upwards towards the neck, where they are fastened to each other by means of a ligament, and have no connexion whatever with the sternum."
Macartney, in Rees's *Cyclopædia.* Article Birds, Anatomy of.

§ 58. The bones of the wing may be compared on the whole to those of the upper extremity in man, or the *quadrumana;* and consist generally of an os humeri; two bones of the forearm; two of the carpus; two, which are generally consolidated together, of the metacarpus; one bone of the thumb; and two fingers; of which that which lies towards the thumb consists of two phalanges, the other only of one. The most remarkable deviation from this structure, in respect to the number, as well as the formation and relative proportion of the bones, is found in the fin-like wings of the *penguin.*† All the bones are here of a very remarkable flattened form, as if they had been pressed; there are two supernumerary bones at the elbow, and the bone of the thumb is entirely wanting.

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* See De Fremery, *Observ. Osteologicæ de Casuario Novæ Hollandiæ.* Ultraject. 1819, p. 25.

† On the wing of the owl, see Heusinger, in Meckel's *Deutsch. Archiv.* vol. vii. p. 177.

§ 59. The bony structure of the lower extremities is more simple in birds than in mammalia. In general it comprehends only the following bones, viz. the femur, the tibia, (to which, in some instances, is added a small, thin, closely adhering pointed fibula), one metatarsal bone, and the toes. On the metatarsal bone of the domestic cock and other birds of the gallinaceous tribe, the spur is situated, a process covered with horn, between which and the genital organs a peculiar sympathy is supposed to exist.* The place of the patella is supplied, in many cases, by a process of the tibia. As birds have neither a true fibula, nor tarsus, their tibia is immediately articulated with the metatarsus. There is, in most of this class, a peculiar progressive increase in the number of phalanges of the toes: the great toe has two; the next, three; the middle one, four; and the outer one, five.† The *psittaci* have, however, a peculiar cross-bone belonging to the great toe; at least I have found it in several skeletons of *psittaci* in my collection. That in the *psittacus erithacus* resembles a short cylindrical bone; in the *psittacus leucocephalus* its formation is rounder.

Birds certainly have a fibula, contrary to the general assertion of the author; but it is small, and soon anchylosed to the tibia.

The lower end of the bone, which answers to the tarsus and metatarsus, forms as many processes as there are toes; and each of these has a pulley for articulation with its corresponding toe.

The vast length of the leg in the wading birds, (*grallæ*) the *ostrich* and *cassowary*, is produced by the tibia, and common bone of the tarsus and metatarsus; for the femur is comparatively short.

The *stork*, and some others of the *grallæ*, which sleep standing on one foot, possess a curious mechanism for preserving the leg in a state of extension, without any, or, at least, with little muscular effort. There arises from the fore-part of the head of the metatarsal bone a round eminence, which passes up between the projections of the pulley, on the anterior part of the end of the tibia. This eminence affords a sufficient degree of resistance to the flexion of the leg, to counteract the effect of the oscillations of the body, and would prove an insurmountable obstruction to the motion of the joint, if there were not a socket within the upper part of the pulley of the tibia, to receive it when the leg is in the bent position. The lower edge of the socket is prominent and sharp, and presents a sort of barrier to the admission of the eminence, that requires a voluntary muscular exertion of the bird to overcome, which being accomplished, it slips in with some force, like the end of a dislocated bone.

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* See Osiander, in Beckman's *Beytrage zur Geschichte der Erfindungen*, vol. v. s. 499.

† Several excellent remarks on this, as well as other parts of the osteology of this class, may be found in Professor Schneider's instructive work, *Commentar. ad reliqua Librorum Frederici 2ndi Imperatoris*, p. 30.

Macartney, *loco citato.*

CHAPTER IV.

ON THE SKELETON OF AMPHIBIA.

§ 60. The general form of the body, and consequently the structure of the skeleton, varies so much, in the first place, in the two orders of this class, viz. the *four-footed amphibia* and the *serpents;* and, secondly, in the three leading classes of the first order, namely, the *testudines*, the *frogs*, and the *lizards;* that it will be best to arrange our observations on this subject according to the natural divisions of the orders and classes.

§ 61. The *testudines*, (turtles and tortoises) whose whole skeleton,* and indeed whose whole body has a very peculiar structure, are entirely toothless; they have, however, a kind of os intermaxillare in the upper jaw. The horny covering of the jaws, particularly the upper one, has some resemblance to the horse's hoof, in the mode of its connexion with the jaw. The cavity, containing the brain, is extremely small, in comparison with the size of the skull; the greatest part of which, in the turtle, is occupied by the large lateral fossæ, holding the eye and the powerful muscles that move the lower jaw.†

This circumstance is still more remarkable in the *crocodile.* The cranium of an individual, measuring thirteen or fourteen feet, will hardly admit the thumb; and the area of its section does not constitute the twentieth part of that of the whole head.

The *chameleon* affords another instance of the same structure: its brain, according to the description of the Parisian dissectors, does not seem larger than a pea; and the whole head, which is of considerable size, consists of the large maxillary bones, the orbits, and immense temporal fossæ, which, not being separated by any partition, give the cranium a very singular appearance.

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* Good representations of the whole skeleton may be found in Coiter, Cheselden, and particularly in J. D. Meyer's *Pastimes, with Considerations of curious Representations of all kinds of Animals*, &c. vol. i. p. 29, vol. ii. p. 62. The individual parts are represented in Giov. Caldesi's *Anatomical Observations relating to Turtles.* Florence, 1687, 4to.

† A masterly delineation and description of the skull of the testudo is given by Dr. Ulrich in his work before quoted.

See the *Description anatomique d'un Caméléon,* &c. or Blasius's *Collection*, tab. 14.

§ 62. The trunk is consolidated with the two great shells of the animal; the dorsal vertebræ and ribs being attached to the upper, the sternum being fixed in the lower or abdominal shell. The upper bony covering, or that of the back, consists of about fifty pieces, which are partly connected together by real sutures.

§ 63. The same bones are found in the pelvis of these animals, as in the mammalia; but the proportion of their relative size is inverted. For instance, the ossa pubis are so deep and broad, that they form the largest flat bones in the whole skeleton, while the ilia are the smallest.

§ 64. The form and position of the scapula and clavicle are the most extraordinary. The former has a most anomalous situation towards the under part of the animal, just behind the abdominal shell; the latter consists of two pieces, joined at an acute angle, to which the humerus is articulated.

§ 65. *Frogs* and *toads** have no real teeth, though the margin of the jaws is denticulated. Their spine is short, and terminates behind in a straight and single bone, which is received into the middle of the somewhat fork-like os innominatum.

§ 66. They have no ribs; but the dorsal vertebræ are furnished with broad transverse processes. The scapula, which is thin and flat, and a pair of bones, corresponding to the clavicle, are joined to the sternum.

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* Skeletons of the frogs and toads of this country (Germany) may be seen in the well known chef d'œuvre of Roesel, *De Ranis nostratibus.* The singular skeleton of the *rana pipa,* (Surinam toad) is accurately described and delineated in the first fascic. of Professor Schneider's *Histor. Amphibior.* It is particularly distinguished by the large lateral processes of the sacrum, and by a bony cavity (*cista Schneid.*) of unknown use, placed behind the sternum, and belonging exclusively, as it should seem, to this animal. See Rudolphi, in F. G. Breyer's *Obs. Anat. circa fabricam Ranæ Pipæ.* Berol. 1812; also the *Rana Paradoxa,* by Lorenz; and C. H. Merten's *Obs. in Osteologiam Batrachorum nostratium.* Hal. 1820.

§ 67. The bones of the fore-arm and of the leg have a peculiarity of structure, in these animals, which deserves notice. These bones consist of a single piece, which is solid in the middle, without any medullary cavity, but divided at either extremity into two conical portions, having manifest medullary cavities.*

§ 68. Among the amphibia of the class of lizards, the *crocodile*† may be taken as an example,‡ on account of many remarkable peculiarities in its structure. In no other animal are the jaws of such immense size, in comparison with the extremely small cavity of the cranium. The anterior part of the upper jaw consists of a large intermaxillary bone, and the lateral portions of the lower maxilla are formed of several pieces joined together. The lower jaw is articulated in a peculiar manner in these animals, although the commencement of this kind of articulation is seen in the jaw of the testudines: it has an articular cavity, in which a condyle of the upper jaw is received. The condyle resembles in some measure, the pulley at the inferior extremity of the humerus, the *trochlea*, or *rotula* of Albinus; this, at least, is the case in the skull of an *alligator*, which I have before me.

The old error of supposing that the upper jaw of the crocodile is moveable, and the lower, on the contrary, incapable of motion, which has been adopted even by such anatomists as Vesalius and Columbus, has perhaps arisen from this peculiar mode of articulation. An examination of the cranium shews, that if the lower jaw remains unmoved, the whole remainder of the skull may be carried backwards and forwards by means of this joint; and such a motion is proportionally easier in the present instance than in any other animal, both on account of the very great relative size of the lower jaw, as well as from its anomalous mode of articulation. There is, however, no motion of the upper jaw-bone only, similar to that which occurs in most birds, serpents, and fishes.

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* See Troja's *Memoir concerning the singular Structure of the Tibia and Ulna in Frogs and Toads,* in his *Experiments on the Regeneration of Bones.* Naples, 1779, p. 250.

† The skeleton of the *crocodile* is represented in N. Grew's *Museum Regalis Societatis.* Lond. 1681; also in Faujas St. Fond, *Histoire Naturelle de la Montagne de St. Pierre de Maestricht.*

‡ The skeleton of the common *green lizard* may be seen in Coiter, pl. 4; Meyer, tom. i. pl. 56; that of the *salamander* and *water-newt* are also given in Meyer; that of the *chameleon* is prefixed to Cheselden's 6th ch.

§ 69. The numerous teeth of crocodiles have this peculiarity of structure, that in order to facilitate their change, there are always two, of which one is contained within the other.*

§ 70. But the most surprising singularity in the skeleton of the crocodile consists in an abdominal sternum, which is quite different from the thoracic sternum, and extends from the ensiform cartilage to the pubis, apparently for the purpose of supporting the abdominal viscera. In the skeletons of three *East Indian crocodiles* which I have examined, there were ten pairs of true, and two of false ribs. The former had bony appendages; and there was a third intermediate portion between the chief piece of the rib and each appendix. The abdominal sternum consisted of seven pairs of cartilaginous arches connected together. The six front pairs were interrupted by open intervals; and the space between the last pair and the pubis was filled by a broad piece of cartilage.†

§ 71. The serpents‡ have an upper jaw, unconnected with the rest of the skull, and more or less moveable of itself.

§ 72. We find in their teeth the important and clearly defined difference, which distinguishes the poisonous species of serpents from the much more numerous innoxious tribes.

The latter have, in the upper jaw, four maxillary bones, beset with small teeth, which form two rows, separated by a considerable interval from each other. One of these is placed along the front edge of the jaw; the other is found more internally, and is situated longitudinally on either side of the palate.

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* Sometimes three, according to Retzius, *Animadvers. circa Crocod.* 1797, 4to.

† A somewhat similar structure in the *crocodile of the Nile* is described by S. Veslingius, in his *Observ. Anat.* p. 43; and in the *alligator*, by Plumier, in the *Mémoires de Trevoux*, of January, 1705, p. 127.

‡ Skeletons of several snakes are contained in the work of Meyer above quoted.

The external row is wanting in the poisonous species; which have, in their stead, much larger tubular fangs connected with the poison bladder, and constituting, in reality, bony excretory ducts, which convey the venom into the wound, inflicted by the bite of the animal.*

§ 73. It appears, in general, that the number of vertebræ in red-blooded animals, is in an inverse proportion to the size and strength of their external organs of motion. Serpents, therefore, which entirely want these organs, have the most numerous vertebræ; sometimes more than 300.

The last vertebræ of the tail, in the *rattlesnake,* are broad, and covered by the first hollow pieces of the *horny rattle:* the succeeding portions of this singular and mysterious organ† are connected to each other in a most curious way.

It may be observed, in confirmation of the remark, with respect to the relation between the vertebræ and the external organs of motion, that the number of vertebræ is very great in fishes of an elongated form, viz. in the *eel,* which has above one hundred. The *porpoise,* which has no organs of motion which deserve mentioning, has between sixty and seventy.

Birds which have such vast power of locomotion by means of their wings, have very few vertebræ, if we consider the anchylosed ones as forming a single piece; and the *frog,* with its immense hinder extremities, has a very short spine, consisting of still fewer pieces.

With regard to the peculiar organ of the rattle-snake above alluded to, Dr. Mead's supposition is by no means improbable, that it may serve to bring birds, &c. within their reach, from the effects of fear its sound produces, in the same manner that the horns of the *cerastes* were formerly imagined, and probably not without justice, to be employed. Major Gardner, a correct and faithful observer, who had long lived in East Florida, affirms, that the young Indians of that country were accustomed to imitate the noise of this serpent, for the purpose of taking squirrels, &c. Vide Blumenbach's *Manual of Natural History*, by Gore, p. 142.

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* Specimens are delineated, for the sake of comparison, in the 4th part of my *Delineations,* &c. tab. 37, where the heads of a rattlesnake (*crotalus*) and a *boa,* are represented with their mouths open.

† For the probable use of this organ, which belongs so exclusively to the *rattlesnake;* and for the assistance which it may afford to this inactive animal, by drawing towards it the frightened birds, (which, indeed, may have given rise to the stories concerning its supposed power of fascination) see Voigt's *Magazine,* vol. i. p. 37, *On the fascinating Power of the Rattlesnake, particularly with respect to a work of Dr. Barton's.*

§ 74. Of all animals, serpents possess by far the greatest number of ribs; which amount, in some, to 250 pairs. It is necessary to mention here the *costæ scapulares* of the *cobra di cabelo*, (*coluber naiæ*) which enable the animal to inflate its neck. This is also the case with other species of the *coluber;* namely, the Egyptian *coluber haje*, which can dilate its neck very considerably when enraged.*

Serpents, with the exception of the *anguis fragilis*, (*blindworm*) are the only red-blooded animals which have no sternum.†

The occiput is connected to the atlas by a single condyle in the *crocodile* and *turtle;* in the *lizard* and *tortoise* there is a slight appearance of division into two surfaces; in the *frog* and *toad* there are two condyles; and in the *serpents* there are three articular surfaces on a single tubercle.

The condyle of the turtle being deeply imbedded in the atlas, the motions of the articulation must be limited: the protraction and retraction of the head in this animal are effected by the flexion and extension of the vertebræ of the neck.

The lower jaw is articulated with an eminence of the cranium in the *lizards, turtles, frogs, salamanders, blindworms*, (*anguis fragilis*) and *amphisbæna;* besides the *crocodile* in which the author mentions it. This bony eminence is compared by Cuvier to the *os quadratum* of birds. The lower jaw only is moveable in these animals. Its articulation in the *turtle* is by means of a ginglymus. In all the venomous serpents the upper jaw is moveable on the head, as in birds: these animals require as extensive an opening of the mouth as possible, since they swallow others whole, which are actually larger than their own body.

Sir Everard Home was led to the discovery of the aid afforded by the ribs of the whole tribe of *snakes* in the progressive motion of those animals by the following circumstances. A *coluber* of unusual size, brought to London to be exhibited, was shewn to sir Joseph Bankes; the animal was lively, and moved along the carpet briskly; while it was doing so, sir Joseph thought he saw the ribs move forward in succession, like the ribs of a caterpillar.

The fact was readily established, and Sir Everard felt the ribs with his fingers as they were brought forward; when a hand was laid flat under the snake, the ends of the ribs were distinctly felt upon the palm, as the animal passed over it. This was an interesting discovery, as it tended to demonstrate a new species of progressive motion, and one widely different from those already known.

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* See Home, *Philos. Trans.* 1804.

† On the part which the ribs perform in the progressive motion of snakes, see Sir Everard Home, in the *Philosophical Transactions* for 1812.

In the *draco volans* the ribs form the skeleton of the wings, by means of which the animal flies, the five posterior ribs being bent backwards and elongated for that purpose, so that in that instance the progressive motion is performed by the ribs, but those particular ribs are superadded for this purpose, and make no part of the organs of respiration, whereas, in the *snake*, the ribs are so constructed as to perform their office with respect to the lungs, as well as progressive motion.

That ribs are not essential to the breathing of all animals, whose lungs are situated in the same manner as in *snakes*, is proved by the *syren* having no ribs; but as this animal has also gills, and can breathe in water as well as in air, the lungs are not so constantly employed, and probably a less perfect supply of air to them may suffice. In animals in general, the ribs are articulated to the back bone by means of a convex surface, which moves upon a slightly concave one formed upon two of the vertebræ, partly on the one and partly on the other, so that there is a rib situated between every two vertebræ of the back; but in the snake tribe, the head of the rib has two slightly concave surfaces, which move upon a convex protuberance belonging to each vertebræ, so that there is a rib to each of the vertebræ.

One advantage of this peculiarity is, that it prevents the ribs from interfering with the motion of the vertebræ on one another. The vertebræ are articulated together by ball and socket joints (the ball being found upon the lower end and the socket on the upper one) and have therefore much more extensive motion than in other animals. The muscles, which bring the ribs forward, consist of five sets, one from the transverse process of each vertebra, to the rib immediately behind it, which rib is attached to the next vertebra. The next set goes from the rib a little way from the spine, just beyond where the former terminates; it passes over two ribs, sending a slip to each, and is inserted into the third; there is a slip also connecting it with the next muscle in succession. Under this is the third set, which arises from the posterior side of each rib, passes over two ribs, sending a lateral slip to the next muscle, and is inserted into the third rib behind it.

The fourth set passes from one rib over the next, and is inserted into the second rib. The fifth set goes from rib to rib. On the inside of the chest there is a strong set of muscles attached to the anterior surface of the vertebræ, and passing obliquely forwards over four ribs to be inserted into the fifth rib, nearly at the middle part between the two extremities. From this part of each rib a strong flat muscle comes forward on each side over the viscera, forming the abdominal muscles, and uniting in a beautiful middle tendon, so that the lower half of each rib, which is beyond the origin of this muscle, and which is only laterally connected to it by loose cellular membrane, is external to the belly of the animal for the purpose of progressive motion, and that half of each rib next the spine, as far as the lungs extend, is employed in respiration.

At the termination of each rib is a small cartilage, in shape corresponding to the rib, only tapering to the point. Those of the opposite ribs have no connexion, and when the ribs are drawn outwards by the muscles, are separated to some distance, and rest through their whole length on the inner surface of the abdominal scuta, to which they are connected by a set of short muscles; they have also a connexion with those of the neighbouring ribs by a set of short straight muscles.

These observations apply to snakes in general; but they have been particularly examined in a *boa constrictor*, three feet nine inches long, preserved in the Hunterian museum. In all snakes, the ribs are continued to the anus, while the lungs seldom occupy more than one-half of the extent of the cavity covered by the ribs. These lower ribs can only be employed for the purpose of progressive motion, and therefore correspond in that respect with the ribs in the *draco volans* superadded to form the wings.

CHAPTER V.

ON THE SKELETON OF FISHES.

§ 75. We should naturally conclude, from observing the great diversity in the general form of fishes, that the structure of their skeleton must be equally various.[*] They agree together, however, on the whole, in having a spine, which extends from the cranium to the tail-fin; and in having the other fins, particularly those of the thorax and abdomen, articulated with peculiar bones destined to that purpose. They have in general many more bones unconnected with the rest of the skeleton, than the animals of the preceding classes.[†]

§ 76. The cranium in several cartilaginous fishes (in the *skate* for instance) has a very simple structure, consisting chiefly of one large piece. In the bony fishes, on the contrary, its component parts are very numerous; amounting to 80 in the head of the *perch.* Most of the latter have a more or less moveable under-jaw.

§ 77. Great variety in the structure of the teeth is observed in this class. Some genera, as the sturgeon, are toothless.

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[*] Delineations of the skeleton of most marine fishes are still wanting. A beautiful view of the *skate* is given by Cheselden, in the beginning of his work; those of the *bream* and *herring* are well delineated and described in Rosenthal's *Icthyotomischen Tafeln,* pt. 1. Berl. 1812. See Fischer's *Zoognosia,* vol. i. Mos. 1813. On the *uranoscopus scaber* (*star-gazer*). Meyer has represented the skeletons of twenty-five fresh-water fishes in the two first volumes of his book, which has been frequently quoted. That of the *carp* may be seen in Duhamel, *Traité des Pêches,* (a part of the great work, entitled *Description des Arts and Métiers,*) pl. 2, sect. 1, tab. 3.

[†] There are some excellent remarks on the skeleton of fishes in general, by Prof. Autenrieth, in Wiedemann's *Archives,* vol. i. p. 2; and by Rosenthal, in Reil's and Autenrieth's *Archiv. fur die Physiol.* vol. x.

On the skeletons of particular orders of fishes, see Vicq d'Azyr, in the 7th vol. of the *Mémoires presentés à l'Acad. des Sciences.* It is translated into German, with remarks and additions by Professor Schneider, in his *Sammlung von Anatomischen Aufsätzen, und Bemerkungen zur Aufklärung der Fischkunde.* Leipzig, 1795, 8vo.

Their jaws, which are distinct from the cranium, form a moveable part, capable of being thrust forwards from the mouth, and again retracted.

§ 78. Those fishes which possess teeth, differ very much in the form, number, and position of these organs. Some species of *bream* (as the *sparus probato-cephalus*) have front teeth almost like those of man:* they are provided with fangs, which are contained in alveoli. In many genera of fishes the teeth are formed by processes of the jaw-bones covered with a crust of enamel. In most of the sharks, the mouth is furnished with very numerous teeth for the supply of such as may be lost. The *white shark* has more than two hundred, lying on each other in rows, almost like the leaves of an artichoke. Those only, which form the front row, have a perpendicular direction, and are completely uncovered. Those of the subsequent rows are, on the contrary, smaller, have their points turned backwards, and are covered with a kind of gum. These come through the covering substance, and pass forward when any teeth of the front row are lost.† It will be understood from this description that the teeth in question cannot have any fangs.

The saw-fish only (*squalus pristis*) has teeth implanted in the bone on both sides of the sword-shaped organ with which its head is armed.

In some fishes the palate, in others the bone of the tongue (as in the *frog-fish*), in others (as in several of the ray-kind) the aperture of the mouth forms a continuous surface of tooth. One of the most surprising formations about the mouth occurs in a West Indian species of *skate* (*raia flagellum*): it is described and delineated by Sloane,‡ as the tongue of the animal. The specimen, which I possess, consists of a flat bone, about five inches long, two broad, and of the thickness of the thumb. It is composed of 15 curved portions, connected together likewise; and each of these arches is covered above with 60 small teeth, which lie close together.

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* Augustin Scilla *De Corporibus Marinis lapidescentibus.* Rome, 1759, 4to. tab. 2.

† See Herissant in the *Mém. de l'Acad. des Sc. de Paris,* 1749, p. 155. And W. Andre, in the *Philos. Trans.* vol. lxxiv. p. 274.

‡ *Philos. Trans.* vol. xix. p. 674.

Many fishes have simple teeth of a *bony substance*, covered by *enamel*, and probably formed as in the mammalia. These are the most common, and may be seen in the *pike*. When the crown has completely appeared, the root becomes anchylosed to the jaw.

In other cases they adhere to the gum only, or at least to a firm cartilaginous substance which covers the jaw. This is exemplified in the *shark*. These teeth seem not to be formed, as those of the mammalia are, by the deposition of successive layers one within the other; but in a manner more nearly resembling the formation of bone. They are at first soft and cartilaginous, and pass by successive gradations into a state of hardness and density not inferior to that of ivory.

A third kind of teeth consists of an assemblage of tubes, covered externally by enamel, and connected to the jaw by a softer substance, which probably sends processes or vessels into those bony tubes. This is the case with the pavement, as we may call it, of teeth, that covers the jaws of the *skate*.

A similar structure is observed in the *anarrichas lupus;* where the teeth, composed of bony tubes, are connected to spongy eminences of the jaws, which may be compared to epiphyses; and on their separation leave a surface like that from which the antler of the deer falls off.

Besides the two jaws, fishes have teeth implanted in the bones of the palate; in that which corresponds to the vomer; in the os hyoides; in the bones which support the branchiæ; and in those which are placed at the top of the pharynx. The *salmon* and *pike* have them in all these situations.

§ 79. In the long-shaped fishes with short fins, the spine consists of a proportionally greater number of vertebræ; of which the eel, for instance, has more than 100, and some sharks even more than 200. The main piece, or body, as it is called, of these vertebræ, is of a cylindrical figure, with a funnel-shaped depression on both surfaces, and concentric rings, which are said to vary in number according to the age of the animal. The spinal marrow passes above these, in a canal formed at the roots of the spinous processes.

The ribs are articulated with what are called the dorsal vertebræ in most of the spinous fishes; but in some they are without this connexion, and in the cartilaginous fishes proper ribs cannot be said to exist.

§ 80. Of the peculiar bones which serve as a basis for the fins, that of the pectoral fin may be compared to the scapula, and that of the abdominal in some measure to the os innominatum.

I possess a specimen of the singular bone,* relating to this subject, which for a long time has been considered a very obscure one. It is thick, of a roundish flat form, and nearly resembling a smooth chestnut in shape and size. It forms on one side a bony point; and on the other is articulated, by means of a very remarkable ginglymus, with two small bones of different magnitude, and resembling the point of an arrow. It belongs most probably to an East Indian *chætodon* (probably to the *chætodon arthriticus* of Schneider); the larger piece being the basis of the back fin, and the smaller constituting the first radii of that fin.†

§ 81. Lastly, many fishes are furnished with merely muscular bones (*ossicula musculorum* of Artedi) which are sometimes bifurcated, are always situated among the muscles, and facilitate their motion.

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* It has been represented in the *Museum Wormianum*, in the *Museum Regium* of Jacobæus, and in Olearius, *Gottolf. Kunstkammer*.

† See W. Bell's *Description of a Chætodon, called by the Malays, Ecan Bonna*, in the *Philos. Trans.* 1793.

CHAPTER VI.

ON THE ŒSOPHAGUS AND STOMACH.

§ 82. After the comparative view which we have now taken of the skeleton, as influencing the general form of the red-blooded animals, we proceed to consider the other parts of the animal structure, and their functions, according to the natural order and series of those functions. The particular classes of animals will be considered in the subdivision of each chapter, according to the arrangement most usually followed in teaching zoology.

§ 83. The *natural functions*, as they are called, which include, in their most extensive sense, the whole process of nutrition, very properly take the lead on this occasion. In the first place, they exist in all classes of animals without exception, though under various modifications; they are indeed common to plants and animals: secondly, the peculiar mode in which they are performed constitutes the most distinguishing character of animals. For they seek their food by voluntary motion, and convey it into the stomach through a mouth. Partial exceptions to this general rule may be drawn, 1st, from those animals in which no mouth has hitherto been discovered; for instance, some *animalcula infusoria*, and in a certain sense some *medusæ*, which, instead of possessing a simple opening, take in their nourishment through many apertures; secondly, from those, in which no manifest voluntary motion has been hitherto observed, as in several real *hydatids*. Physiologists have gone further, and have declared certain organized bodies, in which neither of the above-mentioned characters, neither a mouth nor voluntary motion, could be discovered, to be animals. Such, for example, are the dropsical bladders occasionally found in the abdomen of persons who have laboured under ascites, (rarely in any animal except man,) in vast numbers, and of various sizes, from that of a goose's egg, to the head of the smallest needle. I have examined a great number of these, which were found in a dropsical old man, whose disease and dissolution are related by Richter, in Loder's *Surgical Journal*, vol. iii. p. 415. These differ in their whole structure, and particularly in the formation of their membranes, much more from the true *hydatids* than from some simple morbid watery cysts, which are met with not unfrequently in warm-blooded animals, and consist so indisputably of a mere unnatural formation of vessels and membranes, that no person could think of ascribing to them an independent animal existence. I have now before me similar cysts from a hen, the largest of which (about the size of a small hen's egg), like those of the above-mentioned patient, were quite unattached; the rest appeared, on the first examination, from their connexion with the ovarium, to be nothing else but *calices*, containing from a morbid cause, lymph instead of yolk.

I have, however, lately dissected a *simia cynomolgus*, whose lungs, liver, and omentum were beset with an abundance of watery cysts of various sizes. The fluid of these cysts contained an innumerable quantity of microscopical bodies, which were found, by the employment of strong magnifying powers, to be *hydatids*, with a well-formed circle of hooks and mouth, and consequently must be considered as true independent animals.

MAMMALIA.

§ 84. We have already shewn, in the second chapter, the most important circumstances relating to the mouth. Many species of the genus *simia*, as well as the *hamster*, (*marmota cricetus*) and some similar species of the *marmot*, are provided with *cheek-pouches*, in which the former, who live on trees, place small quantities of food as a reserve: the latter employ these bags to convey their winter provision to their burrows.*

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* An accurate description and delineation of these bags may be found in Sulzer's *Versuch der Naturgeschichte des Hamsters*, pp. 41, 58, tab. 3, fig. 1: one of the most masterly zoological and zootomical monographs that has ever been published.

A cheek-pouch exists also in the *ornithorhynchus paradoxus*. Phil. Trans. 1800, part 1, tab. 2, fig. 2.

The *salivary glands* of the mammalia exhibit very few variations in structure. They are small in the *carnivora*, as mastication, properly so called, can hardly be said to take place in them. On the contrary, the *ruminantia* and *solipeda* have them very large. The size of the sub-maxillary gland, in particular, is remarkable in the *cow* and *sheep:* it extends along the side of the larynx, quite to the back of the pharynx.

The parotid and sublingual glands do not exist in the *amphibious mammalia*, as the *seal:* the teeth of that animal are only adapted for seizing their prey, and must be utterly incapable of mastication. The same remark may be made on the *cetacea*, where the salivary system seems to be altogether deficient.

The mucous glands, which constitute the *labiales* and *buccales* of man, are larger and more distinct in some animals. There is a row of these opposite to the molar teeth of the *dog* and *cat*, penetrating the membrane of the mouth by several small openings. There is also a considerable gland in the *dog*, under the zygoma, and covered by the masseter. Its duct, equal in size to that of the parotid, or sub-maxillary glands, opens at the posterior extremity of the alveolar margin of the upper jaw. The molar glands and their openings are very conspicuous in the *pig*. The *cow* and *sheep* have an assemblage of similar glands in the zygomatic fossa: their excretory ducts open behind the last superior molar tooth.

§ 85. The peculiar glandular and moveable bag, *(bursa faucium)* which is placed behind the palate, has hitherto been only observed in the camels of the old world: and it probably serves to lubricate the throat of these animals in their abode in the dry sandy desarts which they inhabit.*

No mammalia possess an uvula, except *man* and the *simiæ*. As the *cetacea* possess no nostrils, they have not of course any velum palati.

The parts about the pharynx in the *cetacea* exhibit a very singular structure. The larynx is elongated, so as to form a pyramidal projection, on the apex of which its opening is found. The projection of this part will divide the pharynx; and the food must pass on either side of the pyramid. A muscular canal extends from the pharynx to the blowing holes, and is attached to the margin of those apertures. The circular fibres of this tube form a sphincter muscle; which, by contracting round the pyramid, cuts off the communication between the blowing holes and the mouth and pharynx.

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* See Home's *Life of J. Hunter*, prefixed to the posthumous work of the latter, on the *blood, inflammation*, &c. p. 41.

§ 86. The œsophagus of quadrupeds is distinguished from that of the human subject by possessing two rows of muscular fibres, which pursue a spiral course and decussate each other. In those carnivorous animals which swallow voraciously, as the *wolf*, it is very large; on the contrary, in many of the larger *herbivora*, and particularly in such as ruminate, its coats are proportionally stronger.*

The opening of the œsophagus into the stomach is marked by some differences, both with regard to its size, and to the mode of termination. We understand, from observing these points, why some animals, as the *dog*, vomit very easily, while others, as the *horse*, are scarcely susceptible of this process,† except in extremely rare instances.

It seems extraordinary, on the first consideration, that the ruminating animals, in whom the passage of the food from the first stomach into the œsophagus is very easy, should not be excited to vomit without such difficulty.

I possess a hair-ball which was discharged by vomiting from the stomach of a cow, which laboured under an affection of the digestive powers. The substance in question was discharged with violence, after the employment of some white hellebore placed under the integuments of the breast.‡

§ 87. The form, structure, and functions of the stomach, are subject to great variety in this class of animals.§ In most carnivorous quadrupeds,‖ particularly those of a rapacious nature, it bears a considerable resemblance, on the whole, to that of the human subject; its form, however, differs in some cases, as in the seal, (*phoca vitulina*) where the œsophagus enters directly at the left extremity, so that there is no blind sac formed in the stomach. In some animals, as in the *lion, bear,* &c., it is divided by a slight contraction in its middle, into two portions. Its coats, particularly the muscular one, are very strong in the *carnivora.* We must not, however, trust implicitly to Roederer, when he says that "the bear has two stomachs, the first and largest of which is formed like that of a carnivorous animal, the second and smaller like that of birds which feed on hard seeds."

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* Grew may be consulted respecting the œsophagus, as well as the whole alimentary canal of several animals of the different classes. See his *Museum Regalis Societatis*.

† See Professor Nebel *De Nosologia Brutorum cum Hominum Morbis comparata*. Giess. 1798.

‡ A more detailed account will be found in Voigt's *Magazin fur den Neuesten Zustand der Naturkunde*, vol. ii. p. 637.

§ See Neergard's *Vergleichende Anatomie der Verdauungswerkzeuge der Saügethiere und Vögel*. Berl. 1806; and Sir E. Home's *Lectures on comparative Anatomy*.

‖ H. C. Schroeder *De Digestione Animalium Carnivororum*. Goett. 1755, 4to.

The truly carnivorous stomach, as well as the human, which in its structure is closely allied to it, is according to Sir E. Home, capable of dividing its cavity into two distinct portions by a transverse contraction of its coats, in which state the cardiac portion is, in length, two thirds of the whole, but, in capacity, much greater, and in several instances, where the opportunity was afforded of examining the part immediately after death, the stomach has been found in this form both in the human body and other animals. This appearance corresponds with the permanent form of the stomach of many other animals. It is not frequently met with, the fibres of the stomach being readily relaxed very soon after death by the motion of the liquid commonly retained in its cavity, and the air which is let loose; so that such contraction is only to be expected where opportunities occur of a very early inspection of the stomach after death. But this appearance in the stomachs of women has been attributed by Soëmmering to the effect of the pressure occasioned by the central bone of their stays.

§ 88. In some *herbivora* the stomach has an uniform appearance externally; but it is divided into two portions internally, either by a remarkable difference in the two halves of its internal coat,* as in the *horse,* or by a valvular elongation of this membrane, as in several animals of the mouse kind. This is also the case in the *hare* and *rabbit,* where also the food in the two halves of the stomach differs very much in appearance, particularly if the animal has been fed about two hours before death.

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* On the whole internal surface of the horse's stomach there are found, in vast abundance, particularly in spring, the larvæ of two species of œstrus, viz. the *œstrus equi* (which Linnæus called *œstrus bovis*), and the *œstrus hæmorrhoidalis,* the true history of which has been elucidated, for the first time in modern days, by that excellent veterinary surgeon, Mr. Bracy Clark, in the *Transactions of the Linnæan Society,* vol. iii. Figures of the *œstrus equi* and its larvæ are given in my *Abbildungen Naturhistor. Gegenstände,* tab. 47, fig. 3, 4, 5.

In the animals alluded to in this paragraph the left half of the stomach is covered with cuticle, while the other portion has the usual villous and secreting surface. The cuticular covering forms a more or less prominent ridge at its termination. The left portion of the cavity may be regarded as a reservoir, from which the food is transmitted to the true digestive organ; and the different states in which the food is found in the two parts of the cavity justify the supposition. Hence these stomachs form a connecting link between those of ruminating animals on one side, and such as have the whole surface villous on the other.

The larvæ of the *œstrus equi* (the *large horse-bot*) attach themselves to every part of the stomach, but are in general most numerous about the pylorus, and are sometimes, but much less frequently, found in the intestines. They hang, most commonly, in clusters, being fixed by the small end to the inner membrane of the stomach, where they adhere by means of two small hooks, or tentacula. When removed from the stomach they will attach themselves to any loose membrane, and even to the skin of the hand; for this purpose they draw back their hooks almost entirely within the skin, till the two points of these hooks come close to each other; they then present them to the membrane, and keeping them parallel till it is pierced through, they expand them in a lateral direction, and afterwards, by bringing the points downwards, or towards themselves, they include a sufficient piece of the membrane with each hook, and thus remain firmly fixed, for any length of time, without any further exertion of the animal. They attain their full growth about the latter end of May, and are coming from the horse from this time to the latter end of June. On dropping to the ground they soon change to the *chrysalis*, and in six or seven weeks the fly appears. This bot is larger and whiter than that of the *œstrus hæmorrhoidalis,* which has a reddish cast, but in its structure, and situation in the animal, resembles the former. It is found, however, to hang about the rectum previously to quitting it, which the large horse-bot never does.

Veterinary practitioners do not seem to have decided hitherto, whether these animals are prejudicial to the horse, nor even whether they may not be actually beneficial. Their almost universal existence, at a certain season, even in animals perfectly healthy, shews that they produce no marked ill effect; yet the holes which they leave, where they were attached to the stomach, could hardly be made without causing some injurious irritation.

For the mode in which these bots get into the stomach, as also for a most interesting general account of their history and structure, see Rees's *Cyclopædia*, art. Bots, which was furnished by Mr. Clarke, and from which the preceding account is borrowed.

§ 89. In some other mammalia, particularly the *herbivorous* ones, this organ consists of two or more portions manifestly distinct externally, and forming as many stomachs. There are two of these in the *hamster*,* three in the *kangaroo*† and *tajaçu*,‡ four in the *sloths*.§

The carnivorous *cetacea* have also a complicated stomach, consisting in some species of three, in others of four, and even of five subdivisions.||

§ 90. The most complicated and artificial arrangement, both with respect to structure and mechanism, is found in the well known four stomachs of the ruminating animals with divided hoofs; of this we shall take as examples, the *cow* and *sheep*.¶

The first stomach, or *paunch*, (*rumen, penula, magnus venter, ingluvies; Fr. le double, l'herbier, la panse*) is by far the largest in the adult animal; not so, however, in the recently born calf or lamb. It is divided externally into two saccular

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* This is excellently described by Sulzer, in his work above quoted.

† *Voyage à la Recherche de la Perouse*, tom. i. p. 134. Cuvier, *Leçons d'Anatomie comparée*, tom. v. tab. 37; and Sir E. Home's *Lectures on comparative Anatomy*, vol. i. 4to. p. 155.

‡ Tyson in the *Philos. Trans.* vol. xiii. p. 364.

§ Daubenton, vol. xiii. p. 54 aud 63; and Wiedemann's *Archives*, vol. i.

|| Tyson's *Anatomy of a Porpoise*. London, 1680, 4to. Hunter in Schneider's *Beyträgen zur Naturgeschicte der Wallfishharten*, 1 th. p. 51. Cuvier, *Leçons d'Anat. comp.* tab. 38, fig. 2; and Home, in the *Phil. Trans.* for 1807, p. 93.

¶ From the multitude of writers who have treated on the stomach of ruminating animals and its functions, I refer to the following only, on account of the plates which they have given, particularly such as exhibit the vast increase of size in the first stomach compared with the fourth, in the early periods of life.

Observ. Anat. Collegii privati Amstelodamensis, pl. 1, p. 12.

Perrault, *Essais de Physique*, vol. iii. p. 211.

J. C. Peyer, *Merycologia*. Basil. 1685, 4to.

J. J. Harderi *Apiarium*, ib. 1687, 4to. p. 16.

Daubenton, tom. iv. tab. 15—18.

P. Camper, *Lessen over de thans Zweevende Viestertefte*. Leeuward, 1769.

H. Vink, *Lessen over de Herkanwing der Runderen*. Rotterd. 1770.

J. Burgogne, in the *Mém. de l'Acad. de Turin, Sc. Phys.* tom. iv. pp. 1 and 309, 1809.

G. Malacarne, in the *Memorie di Fis. della Soc. Italiana*, tom. xvii. 1815.

Russel's *Natural History of Aleppo*, vol. ii. p. 425, 1794.

To which may be added Sir E. Home's observations on the camel's stomach; which are illustrated by two excellent views of the cow's stomach by Mr. Clift, besides those of the camel. *Philos. Trans.* 1806, pl. 15, 16.

appendices at its extremity, and it is slightly separated into four parts on the inside. Its internal coat is beset with innumerable flattened papillæ. It is generally in this first stomach, seldom in the second, that morbid concretions are formed, of a globular, or elongated, but yet rounded figure. They are composed of three kinds of substances: viz., of hairs, of the undigested fibrous parts of plants, or of stony matters.

The hair-balls, particularly in the cow, are formed of the animal's own hair, which is licked off, and gradually accumulated in the stomach. These either retain a hairy appearance externally, or they are covered with a dark polished substance, similar to that which accumulates round their molar teeth. (See § 24.)

The balls of the *chamois,* (*ægagropilæ*) consisting of vegetable matters, particularly of the macerated fibres of the *æthusa meum,* are found in the animals from which they derive their name, and are generally of a fine spongy texture, covered externally with a smooth black coat.

Of the stony concretions which constitute the *bezoars,* the oriental ones are derived from the *wild goats;* the western come from the South American species of camel. The latter are of a yellow-grey colour; the former of a greenish-black, with concentrical strata, and generally containing for a nucleus a small bit of rice-straw.

In a large *oriental bezoar,* which I sawed through, the nucleus consists of a red-brown, fine but compact spongy substance, like that of the vegetable balls.

The second stomach, *honeycomb bag, bonnet,* or *king's-hood,* (*reticulum arsineum, ollula; Fr. le bonnet, le reseau*) may be regarded as a globular appendage of the paunch; and is distinguished from the latter part by the elegant arrangement of its internal coat, which forms polygonal and acute-angled cells, or superficial cavities.

The third stomach, which is the smallest, is called the *manyplus,* which is a corruption of *manyplies* (*echinus, conclave, centipellio, omasum; Fr. le feuillet, le pseautier*); it is distinguished from the two former, both by its form, which has been compared to that of a hedge-hog when rolled up, and by its internal structure. Its cavity is much contracted by numerous and broad duplicatures of the internal coat, which lie lengthwise, vary in breadth in a regular alternate order, and amount to about forty in the sheep, and one hundred in the cow.

The fourth, or the *red*, (*abomasum, faliscus, ventriculus intestinalis; Fr. la caillette*) is next in size to the paunch, of an elongated pyriform shape, with an internal villous coat like that of the human stomach, with large longitudinal folds.

§ 91. The three first stomachs are connected with each other, and with a groove-like continuation of the œsophagus, in a very remarkable way. The latter tube enters just where the three first stomachs approach each other; it is then continued with the groove, which ends in the third stomach. This groove is therefore open to the first stomachs, which lie to its right and left. But the thick prominent lips, which form the margin of the groove, admit of being drawn together so as to form a complete canal, which then constitutes a direct continuation of the œsophagus into the third stomach.

§ 92. The functions of this very singular part will vary, according as we consider it in the state of a groove, or of a closed canal. In the first case, the grass, &c. is passed, after a very slight degree of mastication, into the paunch, as into a reservoir. Thence it goes in small portions into the second stomach, from which, after a further maceration, it is propelled, by a kind of antiperistaltic motion, into the œsophagus, and thus returns into the mouth. It is here ruminated, and again swallowed, when the groove is shut, and the morsel of food, after this second mastication, is thereby conducted directly into the third stomach.* During the short time which it probably stays in this situation between the folds of the internal coat, it is still further prepared for digestion, which process is completed in the fourth, or true digestive stomach.

The process of rumination supposes a power of voluntary motion in the œsophagus; and indeed the influence of the will throughout the whole process is incontestable. It is not confined to any particular time, since the animal can delay it according to circumstances, when the paunch is quite full. It has been expressly stated of some men who have had the power of ruminating, (instances of which are not very rare,) that it was quite voluntary with them. I have known four men who ruminated their vegetable food: they assured me that they had a real enjoyment in doing this, which has also been observed of others: and two of them had the power of doing or abstaining from it at their pleasure. I have already, on another occasion, observed that the final purpose of rumination, as applicable to all the animals in which it takes place, and the chief utility of this wonderfully complicated function in the animal economy, are still completely unknown; what has been already suggested on these points is quite unsatisfactory.

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* These facts were understood by Severino, who says, in his instructive *Zootemia Democritea*, "A penula et ollula media revomitur ad os, hinc ruminatum ad conclave descendit, et hinc postremo ad ventriculum propriè dictum."

Fabricius ab Aquapendente has sufficiently refuted the visionary notion of Aristotle and Galen, namely, that rumination supplies the place of incisor teeth, the materials of which are applied, in these animals, to the formation of horns. Perrault and others supposed that it contributed to the security of these animals, which are at once voracious and timid, by shewing the necessity of their remaining long employed in chewing in an open pasture. But the *Indian buffalo* ruminates, although it does not fly even from a lion, but rather attacks, and often vanquishes that animal; and the *wild goat* dwells in Alpine countries, which are inaccessible to beasts of prey.

The food of carnivorous animals approaching in its constituent elements more nearly to those of the animal than that of the herbivorous tribes, is more easily reduced into the state which is required for the nourishment of the body in the former than in the latter case. Hence arises a leading distinction between the stomachs of these classes. In the latter animals, the œsophagus opens considerably to the right of the great extremity, so as to leave a large *cul de sac* on the left side of the stomach; and the small intestine commences near the cardia, leaving a similar blind bag on the right. The food must be detained for a long time in such a stomach, as the passage from the œsophagus to the pylorus is indirect and highly unfavourable to speedy transmission. Animals of the *mouse kind* and the *rodentia* shew this structure very well; it is very remarkable in the *mus quercinus*, (Cuvier, *Léçons d'Anatomie comparée*, tom. v. pl. 36, fig. 11). In the *carnivora*, the stomach, which is of a cylindrical form, has no *cul de sac;* the œsophagus opens at its anterior extremity, and the intestine commences from the posterior; so that every thing favours a quick passage of the food. Animals of the *weasel* kind, which are strictly carnivorous, exhibit this structure the most completely. The *seal* and the *lion* also exemplify it. (Cuvier, pl. 36, fig. 7.)

§ 93. There are still two peculiarities in the stomachs of some mammalia, which must be mentioned here, before we proceed to consider that of birds.

In the *opossum*, the two openings of the stomach are placed as near, or even nearer together than in many birds, contrary to the usual rule in this class of animals.

There is a peculiar glandular body at the upper orifice of the *beaver*'s stomach, about the size of a shilling, full of cavities that secrete mucus. It resembles, on the whole, the *bulbus glandulosus* of birds, and assists in the digestion and animalization of the dry food which this curious animal takes, consisting chiefly of the bark and chips of trees, &c.

The stomach of the *pangolin* (*manis pentadactyla*) is almost as thick and muscular as that of the gallinaceous fowls, and contains, like that of granivorous birds, small stones and gravel, which are probably swallowed, for the same purpose, as in the case of those birds: that is to say, they are not swallowed, as Burt* supposed, to afford nourishment; but in order to kill and bruise the insects, &c. which form the ordinary food of the animal, and which might otherwise, by means of their vitality, resist the chemical action of the gastric juice; as the *intestinal worms* and *water-newts*, which have been swallowed, do in man and other mammalia.

According to Cuvier, there is a gland, as large as the head of a man, situated between the coats of the stomach in the *manati* (*trichechus manatus borealis*). It is placed near the œsophagus, and discharges, on pressure, a fluid like that of the pancreas by numerous small openings.

Léçons d'Anat. comp. tom. iii. p. 401.

Sir E. Home is of opinion that a glandular structure exists in the stomach of the *sea-otter* near the pylorus; *Philos. Trans.* 1796, pl. 2; and Mr. Macartney has discovered an arrangement of glandular bodies in the *dormouse*, round the œsophagus just before its termination, similar in situation and appearance to the gastric glands of birds.

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* *Asiatic Researches,* vol. ii.

The stomach of the *ornithorhynchus hystrix* is covered with cuticle, and possesses sharp, horny papillæ near the pylorus. The animal swallows sand, which may probably assist in the reduction of the food, as the gravel does which is swallowed by the gallinaceous birds. Sir E. Home, in the *Phil. Trans.* 1802, p. 2.

The peculiar structure of the stomachs of the *kangaroo, camel,* and *lama,* which is scarcely noticed in the text, deserves a detailed examination. The stomach of the *kangaroo* differs in many particulars from that of any other known animal, and bears a greater resemblance to the human cœcum and colon than to any stomach. The œsophagus enters the stomach very near its left extremity, which, unlike the corresponding part in other animals, is very small and bifid. From the entrance of the œsophagus the cavity extends towards the right side of the body, then passes upwards, makes a turn upon itself, crosses over to the left side before the œsophagus, and again crosses the abdomen towards the right, making a complete circle round the portion into which the œsophagus enters, and terminates by a contracted orifice at the pylorus.

Its cavity gradually enlarges from the left extremity through its whole course, till it approaches the pylorus; it then contracts and dilates again into a rounded cavity with two lateral processes: beyond this is the pylorus, the orifice of which is very small. On the anterior and posterior side of the stomach there is a longitudinal band, similar to those of the human colon, beginning faintly at the left termination, and extending as far as the enlargement near the pylorus; these bands being shorter than the coats of the stomach, the latter are consequently puckered, forming sacculi, as in the human colon.

When the cavity of the stomach is laid open, the cuticular lining of the œsophagus is found to be continued over the portion immediately below it, and extends to the termination of the smallest process at the left extremity, and nearly to the same distance in the opposite direction; the cuticular covering is very thin, and extremely smooth.

The lining of the larger process at the left extremity is thick and glandular, and in the living body probably receives no part of the food, but is to be considered as a glandular appendage.

On the right of the œsophagus the cuticle does not end by a transverse line, but terminates first upon the middle of the great curvature, where a villous surface begins by a point, and gradually increases in breadth till it extends all round the cavity; its origin, therefore, is in the form of an acute angle. The villous surface is continued over the remaining cavity as far as the longitudinal bands extend; and that half of it next the pylorus has three rows of clusters of glands: one row is situated along the great curvature, and consists of fifteen in number; the other two rows are close to the two longitudinal bands, and consist only of nine. Besides these there are two large clusters of an oblong form, situated transversely, where the longitudinal bands terminate. The internal surface of the rounded cavity next the pylorus has a different structure, putting on a tesselated appearance, formed by a corrugated state of the membrane. Immediately beyond the pylorus is a ring of a glandular structure surrounding the inner surface of the duodenum.

The stomach of the *kangaroo*, in the peculiarities of its structure, forms an intermediate link between the stomachs of animals which occasionally ruminate; those which have a cuticular reservoir; and those with processes or pouches at their cardiac extremity, the internal membrane of which is more or less glandular. The *kangaroo* is found to ruminate when fed on hard food. This was observed by Sir Joseph Banks, who had several of these animals in his possession, and frequently amused himself in observing their habits. It is not, however, their constant practice, since those kept in Exeter Change have not been detected in that act. This occasional rumination connects the kangaroo with the ruminant. The stomach having a portion of its surface covered by cuticle, renders it similar to those with cuticular reservoirs; and the small process from the cardia gives it the third distinctive character; indeed it is so small, that it would appear as if it were placed there for no other purpose.

The *kangaroo*'s stomach is occasionally divided into a greater number of portions than any other, since every part of it, like a portion of intestine, can be contracted separately; and when its length and the thinness of its coats are considered, this action becomes necessary to propel the food from one extremity to the other.

Such a structure of stomach makes regurgitation of its contents into the mouth very easily performed. The food in the stomach goes through several preparatory processes; it is macerated in the cuticular portions; it has the secretion from the pouch in the cardia mixed with it, and is occasionally ruminated. Thus prepared, it is acted on by the secretion of the gastric glands, which probably are those met with in clusters in the course of the longitudinal bands, and afterwards converted by the secretions near the pylorus into chyle.—See Sir E. Home's *Lectures on comparative Anatomy*, vol. i. p. 155, 4to. edit. to which work we are also indebted for the following excellent account of the structure of the stomach of the *camel*. The structure of this part in the *lama*, according to the account which Cuvier has given of it in the examination of a fœtus, (*Léçons d'Anat. comparée*, tom. iii. p. 397,) does not differ essentially from that of the camel.

Opportunities of examining the camel rarely occur in this country. One of these, however, was met with thirty years ago, and the late Mr. Hunter availed himself of it, and made several preparations to illustrate the different parts of its structure, which are now in the collection at the College of Surgeons. As the stomach was blown up, and preserved in a dry state, many peculiarities were left unexamined, particularly those respecting the power which the animal has of carrying a provision of water as a supply when traversing the deserts.

Sir E. Home was led by many circumstances to be very desirous of investigating this subject, and in the year 1805, a favourable opportunity presented itself; a camel in a dying state having been purchased by the board of curators of the College of Surgeons, with a view of illustrating the anatomy of that animal.

As Professor of Comparative Anatomy, Sir E. Home was directed to examine the peculiarities of the stomach, and to make a report on that subject.

The *camel*, the subject of the following observations, was a female, brought from Arabia, twenty-eight years old, and said to have been twenty years in England, and twelve years in the possession of the person from whom the Board of Curators purchased it. Its height was seven feet from the ground to the tip of the anterior hump.

In December, 1805, when it was purchased by the college, it was so weak, as hardly to be able to stand: it got up with difficulty, and almost immediately kneeled down again.

By being kept warm, and well fed, it recovered so as to be able to walk, but was exceedingly infirm on its feet, and moved with a very slow pace.

It drank regularly every second day six gallons of water, and occasionally seven and a half, but refused to drink in the intervening period. It took the water by large mouthfuls, and slowly, till it had done. The quantity of food it daily consumed, was one peck of oats, one of chaff, and one-third of a truss of hay.

In the beginning of February, 1806, it began to shed its coat. Towards the end of March the wind became extremely cold, and the animal suffered so much from it, that it lost its strength, refused its food, and drank only a small quantity of water at a time.

In this state it was thought advisable to put an end to so miserable an existence, and it suggested itself to the committee appointed for the purposes of this investigation, that if this was done soon after the animal had drunk a quantity of water, the real state of the stomach might be ascertained.

On the second day of April, by giving the animal hay mixed with a little salt, it was induced to drink, in the course of two hours, three gallons of water, not having taken any the three preceding days, or shewn the least disposition to do so.

Three hours after this, its head was fixed to a beam to prevent the body from falling to the ground after it was dead; and in this situation it was pithed by Mr. Cline, junior, assisted by Mr. Brodie and Mr. Clift.

This operation was performed with a narrow, double-edged poniard passed in between the skull and first vertebra of the neck; in this way the medulla oblongata was divided, and the animal immediately deprived of sensibility.

In the common mode of pithing cattle, the medulla spinalis only is cut through, and the head remains alive, which renders it the most cruel mode of killing animals that could be devised.

The animal was kept suspended, that the viscera might remain in their natural state, and in two hours the cavities of the chest and abdomen were laid open.

The first stomach was the only part of the contents of the abdomen which appeared in view. The smooth portion of the paunch was on the left side, and on the right towards the chest was a cellular structure, in which it was evident to the feeling that there was air; but no part of the solid food with which the general cavity was distended. On the lower posterior part, towards the pelvis, there was another portion made up of cells, larger and more extensive than that which was anterior. On pressing on this part, a fluctuation of its contents could be distinctly perceived. A trochar with the canula was plunged into the most prominent of the cells, and on withdrawing it, there passed through the canula twelve ounces of water of a yellow colour, but unmixed with any solid matter.

This fact having been ascertained, the first cavity was laid open on the left side, at a distance from the cellular structure, and the solid contents were all removed.

While this was doing, some water flowed out of the cells, and some out of the second cavity, but the greater part was retained.

That in the second cavity was found nearly pure, while the other was muddy, and of a yellow colour, tinged by the solid contents of the first cavity.

On examining the cellular structure, no part of the solid food had entered it, nor was there any in the second cavity; those cavities having their orifices so constructed as to prevent the solid food from entering even when empty.

On measuring the capacities of these different reservoirs in the dead body, they were as follows: The anterior cells of the first cavity were capable of containing one quart of water when poured into them. The posterior cells three quarts. One of the largest cells held two ounces and a half, and the cells of the second cavity four quarts. This, however, must be considered as much short of what those cavities can contain in the living animal, since there are large muscles covering the bottom of the cellular structure, to force out the water, which must have been contracted immediately after death, and by that means had diminished the cavities.

By this examination it was proved, in the most satisfactory manner, that the camel, when it drinks, conducts the water in a pure state, into the second cavity; that part of it is retained there, and the rest runs over into the cellular structure of the first, acquiring a yellow colour in its course.

This confirms the account given by M. Buffon, in his examination of the *camel*'s stomach, as well as that of travellers, who state that when the camel dies in the desert, they open the stomach and take out the water which is contained in it to quench their thirst.

That the second cavity in the *camel* contained water had been generally asserted, but by what means the water was kept separated from the food, had never been explained, nor had any other part been discovered by which the common offices of a second cavity could be performed. On these grounds Mr. Hunter did not give credit to the assertion, but considered the second cavity of the *camel* to correspond in its use with that of other ruminants, as appears from his observations on the subject, stated by Dr. Russel in his history of Aleppo.

The difference of opinion on this subject led Sir Everard to examine accurately the structure of the stomach of the *camel*, and of those ruminants which have horns; so as to determine, if possible, the peculiar offices belonging to their different cavities.

The *camel*'s stomach anteriorly forms one large bag, but when laid open, this is found to be divided into two compartments, on its posterior part by a strong ridge, which passes down from the right side of the orifice of the œsophagus, in a longitudinal direction. This ridge forms one side of a groove that leads to the orifice of the second cavity, and is continued on beyond that part, becoming one boundary to the cellular structure met with in that situation. From this ridge, eight strong muscular bands go off at right angles, and afterwards form curved lines, till they are insensibly lost in the coats of the stomach. These are at equal distances from each other, and, being intersected in a regular way by transverse muscular septa, form the cells.

This cellular structure is in the left compartment of the first cavity, and there is another of a more superficial kind on the right, placed in exactly the opposite direction, made up of twenty-one rows of smaller cells, but entirely unconnected with the great ridge.

On the left side of the termination of the œsophagus, a broad muscular band has its origin from the coats of the first cavity, and passes down in the form of a fold parallel to the great ridge, till it enters the orifice of the second, where it takes another direction. It is continued along the upper edge of that cavity, and terminates within the orifice of a small bag, which may be termed the third cavity.

This band on one side, and a great ridge on the other, form a canal which leads from the œsophagus down to the cellular structure in the lower part of the first cavity.

The orifice of the second cavity, when this muscle is not in action, is nearly shut; it is at right angles to the side of the first. The second cavity forms a pendulous bag, in which there are twelve rows of cells, formed by as many strong muscular bands, passing in a transverse direction, and intersected by weaker muscular bands, so as to form the orifices of the cells. Above these cells, between them and the muscle which passes along the upper part of this cavity, is a smooth surface extending from the orifice of this cavity to the termination in the third.

From this account it is evident, that the second cavity neither receives the solid food in the first instance, as in the *ruminantia*, nor does the food afterwards pass into the cavity or cellular structure.

The food first passes into the first compartment of the first cavity, and that portion of it which lies in the recess, immediately below the entrance of the œsophagus, under which the cells are situated, is kept moist, and is readily returned into the mouth along the groove formed for that purpose, by the action of the strong muscle, which surrounds this part of the stomach, so that the cellular portion of the first cavity in the *camel* performs the same office as the second in the ruminants with horns.

While the camel is drinking, the action of the muscular band opens the orifice of the second cavity at the same time that it directs the water into it; and when the cells of that cavity are full, the rest runs off into the cellular structure of the first cavity immediately below, and afterwards into the general cavity. It would appear that camels, when accustomed to go journeys, in which they are kept for an unusual number of days without water, acquire the power of dilating the cells, so as to make them contain a more than ordinary quantity as a supply for their journey; at least such is the account given by those who have been in Egypt.

When the cud has been chewed, it has to pass along the upper part of the second cavity, before it can reach the third. How this is effected without its falling into the cellular portion, could not, from any inspection of dried specimens, be ascertained; but when the recent stomach is accurately examined, the mode in which this is managed becomes very obvious.

At the time that the cud is to pass from the mouth, the muscular band contracts with so much force, that it not only opens the orifice of the second cavity, but acting on the mouth of the third, brings it forward into the second, by which means the muscular ridges that separate the rows of cells are brought close together, so as to exclude these cavities from the canal through which the cud passes.

It is this beautiful and very curious mechanism which forms the peculiar character of the stomach of the *camel*, *dromedary*, and *lama*, fitting them to live in the sandy desarts, where the supplies of water are very precarious.

The first and second cavities of the *camel*, as well as those of the *ruminantia*, are lined with a cuticle.

The third cavity in the *camel* is so small, that were it not for the distinctness of its orifices, it might be overlooked. It is nearly spherical, four inches in diameter, is not like the third of the *ruminantia*, lined with a cuticle, nor has it any septa projecting into it. The cuticle, continued from the second cavity, terminates immediately within the orifice of the third, the surface of which has a faint appearance of honey-combed structure; but this is so slight as to require a close inspection to ascertain it.

This cavity can answer no other purpose in the œconomy of the animal, than that of retarding the progress of the food, and making it pass by small portions into the fourth cavity; so that the process, whatever it is, which the food undergoes in the third cavity of other ruminants, would appear to be wanting in the *camel*, and consequently not required.

The fourth cavity lies to the right of the first, and has for a great part of its length the appearance of an intestine; it then contracts partially, and the lower portion has a near resemblance in its shape to the human stomach. Its whole length is four feet four inches; when laid open, the internal membrane of the upper portion is thrown into longitudinal narrow folds, which are continued for about three feet of its length; these terminate in a welted appearance; the ridges are as large as in the *bullock,* but not so prominent nor so serpentine in their course, and for the last nine inches the membrane has a villous appearance, as in the human stomach. Close to the pylorus there is a glandular substance of a conical form, which projects into the cavity, the blunt end of it resting upon the orifice of the pylorus. This is similar to what is met with in the *bullock*, but still more conspicuous.

The fourth cavity of the *camel* corresponds with that of the *bullock* in all the general characters, and resembles it in most particulars. It exceeds it in length; but the plicæ are so much smaller, that the extent of the internal surface must be very nearly the same in both. It differs from it in having a contraction in a transverse direction, immediately below the termination of the plicated part, which has led both Daubenton and Cuvier to consider these two portions as separate cavities.

On a comparative view of the stomach of the *bullock* and *camel,* it appears that in the *bullock* there are three cavities formed for the preparation of the food, and one for digestion. In the *camel,* there is one cavity fitted to answer the purposes of two in the *bullock;* a second employed as a reservoir for water, having nothing to do with the preparation of the food; a third so small and simple in its structure, that it is not easy to ascertain its particular office. It cannot be compared to any of the preparatory cavities of the *ruminantia,* as all of them have a cuticular lining, which this has not; we must therefore consider it as a cavity peculiar to ruminants without horns, and that the fourth is the cavity in which the process of digestion is carried on.

In the stomachs of ruminating animals, the processes which the food undergoes before it is converted into chyle, are more complex than in any others. It is cropped from the ground by the fore-teeth, then passes into the paunch, where it is mixed with the food in that cavity; and it is deserving of remark, that a certain portion is always retained there; for although a *bullock* is frequently kept without food several days before it is killed, the paunch is always found more than half full; and as the motion in that cavity is known to be rotatory, by the hair balls found there being all spherical or oval, with the hairs laid in the same direction, the contents must be intimately mixed together. The food is also acted upon by the secretions belonging to the first and second cavities; for although they are lined with a cuticle, they have secretions peculiar to them. In the second cavity these appear to be conveyed through the papillæ, which in the deer are conical; and when examined in a lens, whose focus is half an inch, they are found to have three distinct orifices, and that part of each papilla next the point is semi-transparent. These secretions are ascertained by Dr. Stevens's experiments to have a solvent power in a slight degree, since vegetable substances contained in tubes were dissolved in the paunch of a sheep.*

The food thus mixed is returned into the mouth, where it is masticated by the grinding teeth; it is then conveyed into the third cavity, in which a gas is emitted. This was examined by Sir Humphrey Davy and Mr. William Brande, and was found to be inflammable, and not to contain carbonic acid, which establishes a difference between this process and fermentation; the food is then received into the upper portion of the fourth cavity.

The changes which are produced on the food in the three first cavities, are only such as are preparatory to digestion; and it is in the fourth alone that that process is carried on. In the plicated portion the food is acted on by the secretion of the gastric glands; in that portion of the fourth cavity of the *deer*'s stomach, small orifices are seen in the internal membrane leading to the cavities, which appear to be the openings of these glands.

In the lower portion the formation of chyle is completed.

BIRDS.

§ 94. As we have spoken above of the *cheek-pouches* of some mammalia, we must here take notice of the *throat sac*, which is found in the male *bustard*, under the integuments of the front of the neck, and opens by a wide aperture under the tongue: its use has not been hitherto discovered.†

A very remarkable dilatation of the fauces occurs in the *pelican*. An immense pouch, capable of holding several quarts of water, lies between the branches of the lower mandible, and constitutes a reservoir for the food, which consists of fishes. By means also of this bag, the animal feeds its young until they are of sufficient strength to provide for themselves.

§ 95. The œsophagus, which generally descends on the right of the trachea, as well as its opening into the stomach, is of immense size in many carnivorous birds; considerably larger indeed than the intestinal canal. The capaciousness of this tube enables it to hold for a time the entire fish, and large bones which these birds swallow, and which cannot be contained in the stomach; and facilitates the discharge, by vomiting, of the indigestible remains of the food, which form balls of hair, feathers, and bony matter. A *sea-gull*, which I kept alive for some years, could swallow bones of three or four inches in length, so that the lower end only reached the stomach, and was digested, whilst the rest projected into the œsophagus, and descended gradually, in proportion as the former was dissolved.*

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* *Dissertatio Physiologica inauguralis de Alimentorum concoctione. Auctore* Edwardo Stevens. Edinb. 1777.

† Edwards's *Natural History of Birds,* tom. ii. tab. 73; and Schneider, *Comment. ad reliqua Librorum, Freder. 2ndi,* tom. ii. p. 9.

Proper salivary glands, such as secrete that clear and limpid fluid constituting the saliva, do not exist in birds. For mastication, or the comminution of the food, and its reduction into a soft paste, to which function these glands are entirely subservient, is not performed in the mouth of these animals, but in their gizzard. Birds, however, have a very copious apparatus of those mucous follicles, which form the *glandulæ labiales, buccales, linguales*, &c. of the human subject. The sides of the tongue, the under surface of that organ, and the entrance of the œsophagus, are beset with numerous openings of these glands, which furnish an abundant supply of viscid mucus to defend the tender lining of these parts from the hard bodies which constitute the food of several birds. These apertures are very conspicuous in the gallinæ. The *ostrich*, in particular, has two flattened bodies at the upper and back part of the palate, which may be compared in some respects to tonsils. The surface of these is covered with innumerable foramina, from which a tenacious mucus may be expressed. The soft palate is entirely deficient in birds: the nostrils open on the bony palate by longitudinal slits, the sides of which are guarded by soft pointed papillæ.

§ 96. The œsophagus expands just before the sternum into the *crop*, (*ingluvies, prolobus; Fr. le jabot*) which is furnished with numerous mucous, or salivary glands, disposed in many cases in regular rows. In such birds as nourish their young from the crop, the glands swell † remarkably at that time, and secrete a greater quantity of fluid.‡ This takes place in an inverse ratio to the age of the young pigeon, as long as the old birds keep their food in the *crop*. This part is found in *land birds* only, but not in all of these; it exists in all the *gallinæ*, and in some birds of prey.*

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* See Morton's *Natural History of Northamptonshire*, p. 353; and Dr. Persoon, in Voigt's *Neuen Magasin*, vol. i. p. 56.

† Hunter *on the Animal Economy*, p. 193; and Neergaard, tab. 5, fig. 2 and 3.

‡ See *Viridet du bon Chyle, pour la Production du Sang*, tom. i. p. 78.

The crop of the *common fowl*, and of the other *gallinæ*, is of a globular form, and placed just in front of the chest. The œsophagus, which opens at its upper part, commences again about the middle of the bag, so that the crop itself forms a *cul de sac*, or bag, out of the regular course of communication between the two openings of the œsophagus. In the *pigeon* there is a spherical bag formed on both sides of the œsophagus, which tube itself is very large in the *pouting pigeon*, and admits of being distended with air, so as to cause the appearance from which the name of the bird is derived. In the birds which we have now mentioned, the crop must be considered as an organ for macerating the dry and hard vegetable substances which constitute the food of these animals. The *accipitres* also have this dilatation; but it must be regarded in them merely as a reservoir for the food which does not require any previous softening. It is wanting in the piscivorous birds; but its place is supplied by the great size of the œsophagus, in which entire fishes are held until they can pass into the stomach. The *heron*, *cormorant*, &c. are examples of this peculiarity.

§ 97. There is another glandular and secretory organ, much more common than the crop, belonging indeed very generally, though it is wanting in some birds, as the *king's-fisher*, to the whole class; this is the *bulbus glandulosus*, (*echinus*, *infundibulum*, *proventriculus*, *corpus tubulosum*) which is situated before the entrance of the œsophagus into the proper stomach, and whose form and structure vary considerably in the different genera and species. In the *ostrich*, for example, its magnitude and form give it the appearance of a second stomach.† In some other birds, as the *psittaci*, *ardeæ*, (*crane*, *stork*, &c.) its appearance is different in form from that of the proper stomach, and its size is larger; while, on the contrary, in gallinaceous birds, it is much smaller.‡

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* See Wolf, in Voigt's *Magazine*, vol. i. p. 72.

† Hence, Valisnieri calls it in this animal, *the first stomach*; see his *Notomia dello Struzzo*, 1713, p. 159; and Cuvier's *Anat. comparée*, tab. 40, fig. 3.

‡ For an account of several other variations in the structure of this part, in different birds, see the Parisian *Mémoires pour servir à l'Histoire Naturelle des Animaux*,

The term *bulbus glandulosus* (*ventricule succenturié,* Cuvier) is applied to a small portion of the œsophagus, just before its termination in the stomach. This part is obviously rather larger and thicker in its coats than the rest of the tube. Its structure may be most clearly discerned in the gallinaceous genera. The œsophagus consists, as in other parts, of its two coats, the muscular and villous; but a vast number of *glandular bodies*, cylindrical in form, and arranged in close apposition to each other, are interposed between these tunics, and entirely surround the tube, constituting the "*zone of gastric glands*," of Mr. Macartney, (Rees's *Cyclopædia*, Art. Birds). These bodies are hollow internally, and open into the cavity of the *bulbus.* The fluid secreted by them, which, from their number and size, must be furnished in great abundance, passes into the gizzard, and mixes with the food in proportion as it is triturated by that organ. These glands are much less distinct in those birds which live on animal food, as the *accipitres* and the *piscivorous genera;* but they exist universally, and their openings can always be discerned. The *ostrich* affords an opportunity of examining them to great advantage. In the *African* species the œsophagus is dilated into an immense bag, capable of holding several pints of water, and is five or six times larger than the gizzard itself, which is placed on the right and anterior part of this dilatation. The glands do not surround the tube, so that the term *zone* would be here inapplicable. They form a long but narrow band, commencing at the termination of the œsophagus, and running along the front of the bag towards the gizzard. This band measures about twelve inches in length, and not more than three at its greatest breadth. The size of the individual glands varies: they are largest in the middle, and decrease towards either margin of the band. Some of them equal a large pea, and their openings are of a proportional size. They are arranged in close apposition to each other, and the inner surface of the pouch is covered by a continuation of the insensible lining of the gizzard, which separates very easily from the surface.

The solvent glands in birds are larger, and more distinct from the other parts of the digestive organs than in the mammalia. The solvent glands in the whole of the extensive genus *falco* of Linnæus are cylindrical bodies, with very small canals, a villous internal surface, and thick coats, open at one end, closed and rounded off at the other; they are placed on the outside of the membrane which lines the cardiac cavity, they lie parallel to one another, and nearly at right angles to the membrane through which they open, the closed end being slightly turned upwards, so as to make the orifice the most depending part. In the *golden eagle* (the *falco chrysaëtos, L.*) and the *sea eagle*, (*falco ossifragus*) they form altogether a broad compact belt; but in the *hawk (falco nisus*) this belt is slightly divided into four distinct portions; immediately below these glands the cavity becomes wider, and is inclosed in a digastric muscle of weak power, with a flat tendon on each side. The internal surface of this cavity, which is the gizzard, is soft and vascular.

In all animals that live on animal food the solvent glands appear to have a similar structure to that which has been just described, only differing in size and situation. In the *solan goose* (*pelecanus bassanus*) these glands are rather larger than in the *eagle*, but are placed in the dilated part of the cavity of the gizzard, forming a complete belt of great breadth, consequently are extremely numerous.

In the *heron* (*ardea cinerea*) they are in the same situation as in the *solan goose;* they are thinly scattered, and do not form a complete belt, being more numerous on the anterior and posterior surfaces. A ball of fish-bones, held together by mucus, was found in the cavity of the gizzard.

In the *cormorant* (*pelecanus carbo*) the situation of the solvent glands is the same as in the solan goose; but they only form two circular spots, one anterior, the other posterior.

In all these birds the inner membrane of the gizzard is soft and smooth, but that portion which covers the solvent glands has a more spongy or villous appearance; and this part secretes a mucus which the other parts do not. This fact appears to be ascertained by the following circumstances: on examining the gizzard of a cormorant that died in consequence of an inflammation in the œsophagus, which had been communicated to the internal membrane of the gizzard, a viscid mucus was found upon the surface covering the solvent glands, and this was not met with in any other part; so that the mucus had been evidently secreted there, and was afterwards coagulated by the liquor of the solvent glands poured upon it, coagulation being the first process which takes place in the act of digestion. This explains the circumstance of ascarides being frequently found enveloped in mucus in this part of the cormorant's gizzard, the mucus on which they feed being secreted in consequence of the irritation they produce on the membrane. In the same manner the flakes in the biliary ducts of the sheep increase the secretion of the bile by irritating these canals, and then feed on it.

In birds that live upon fish and sea insects with crustaneous coverings, as the *sea-gull*, (*larus canus*) the gizzard has a horny cuticular lining, and the solvent glands are in the same situation as in the genus *falco*.

In those birds that live on land insects, some of whose coverings are soft, others hard, there is a difference in the structure of the digestive organs from what has been described. The solvent glands are placed in a triangular form in the cardiac cavity, and immediately under it is a small gizzard with a horny lining. Of this kind is the *wood-pecker* (*picus minor*).

There is still another variety in the structure of these organs. In the *little auk* (the *alca alle*) the solvent glands are spread over a greater extent of surface than in any other bird that lives on animal food, and the form of the digestive organs is peculiar to itself. The cardiac cavity appears to be a direct continuation of the œsophagus, distinguished from it by the termination of the cuticular lining, and the appearance of the solvent glands. The cavity is continued down with very gradual enlargement below the liver, and is then bent up to the right side, and terminates in a gizzard; when the cavity is laid open, the solvent glands are seen at its upper part, every where surrounding it, but lower down they lie principally upon the posterior surface, and where it is bent upwards, towards the right side, they are entirely wanting. The gizzard has a portion of its anterior and posterior surfaces opposite each other, covered with a horny cuticle.

In birds that live principally on vegetable food, the solvent glands have a different structure, according to the substances the birds are intended to feed upon, and vary in situation according to the habits of life.

In the *pigeon* (*columba domestica*) their situation is the same as in the genus *falco*, but their size is small, the external orifices large, and the coats thin, so that they resemble the glands in the English heron, having however larger cavities.

In the *swan* (*anas cygnus*) the solvent glands appear to be cylinders, as in the genus *falco*, but are not straight, bending upon one another in a direction obliquely upwards; their internal surface is not villous, but rather broken and irregular.

In the *goose* (*anas anser*) they have the same situation, but when laid open, the sides are found to be cellular.

In the *common fowl* (*phasianus gallus*) these glands are made up of four small short processes uniting in a middle tube, which opens externally by one orifice.

In the *turkey* (*meleagris gallopavo*) they consist of four small processes, which diverge from each other in opposite directions.

In many large birds that only walk and run, their wings being too small to enable them to fly, the digestive organs are formed in many respects differently from those of other birds.

In the *cassowary* (*cassuarius emu*) the solvent glands are situated between the crop and gizzard, as in many other birds, but this part is dilated into a large cavity, and separated from the gizzard by an oblique muscular valve; in this cavity the food may be retained for some time, but cannot be triturated there, since the stones and other hard bodies swallowed will readily force a passage into the gizzard.

In the *American ostrich* (*rhea Americana*) the solvent glands are fewer in number than in other birds. They only occupy a small portion of a circular form on the posterior side of the cardiac cavity; this however is compensated by the complex structure of which they are composed. To each gland there is one common orifice; when the cavity to which it leads is laid open, three smaller orifices are exposed, each of which communicates with five or six processes like the fingers of a glove. The structure is similar to that of the solvent glands of the *beaver* among quadrupeds. The cardiac cavity in which the glands are situated is dilated to a large size, as in the cassowary, and there is a similar muscular valve, separating it from the gizzard. The digastric muscle is weak, but the fibres of which it is composed, and tendons between the two bellies of the muscle, are beautifully distinct.

In the *African ostrich* (*struthio camelus*) the solvent glands are unusually numerous ; the space in which they are situated is not only dilated into a cavity, but is continued down below the liver, and then bent up upon itself towards the right side, where it terminates in a strong gizzard nearly at the same height as the beginning of the cardiac cavity. The gizzard is unusually small, the grinding surfaces do not admit of being separated to a great distance from one another ; and on one side there are two grooves, and two corresponding ridges on the other. Beyond the cavity of the gizzard is an oval aperture, with six ridges, covered with cuticle, to prevent any thing passing out of the gizzard till it is reduced to a small form. The cardiac cavity of one of these birds was found to contain stones of various sizes, pieces of iron, and halfpence ; but, between the grinding surfaces of the gizzard, there were only broken glass-beads, of different colours, and hard gravel mixed with the food. The cassowary and American ostrich differ from birds that fly, in having the solvent glands placed in a cavity of unusual size, and the muscular structure of the gizzard uncommonly weak ; their mode of progression, which is a kind of run, producing so much agitation between the stones and the food, as to render a strong muscular action unnecessary.

In the *ardea argala*, a native of Bengal, which feeds upon carrion, and is exceedingly voracious, the solvent glands are differently formed from those of any other bird ; each gland is made up of five or six cells, and these open into one common excretory duct. The glands are disposed in two circular masses, one on the anterior, the other on the posterior surface of the cardiac cavity, putting on a similar appearance to those of the cormorant, but differing both in structure and situation. The gizzard is lined with a horny cuticle, nearly of the same general appearance as that of the crow, and the digastric muscle is of similar strength.

In the *parrot* tribes, which feed principally on seeds and fruits, there is a different formation of the digestive organs. There is a crop on the right side, as in the fowl, but the cardiac portion is unusually large, and the gastric glands are spread over a considerable portion of its surface, but are wanting at the lower part, and immediately below there is a regularly formed gizzard of a very diminutive size. In this respect the *parrot* accords very nearly in its digestive organs to the wood-peckers among those birds that live upon animal food, having a cavity in which the soft substances may be acted upon by the gastric liquor, and also a gizzard, in which any harder substances may be broken down, and by that means rendered fit to be acted upon by the secretion of the gastric glands.

In examining the gastric glands of the Java swallow Sir E. Home thought that he saw an obvious difference between the appearance of the orifices, by which the secretion is forced into the gizzard of this bird, and that of the common swallow. But Mr. Clift, who saw the preparation to which Sir Everard alludes, has assured the editor that he could not perceive the difference which Sir Everard mentions.

Sir E. Home concludes, from a comparison of the peculiarities in the structure of the digestive organs in birds generally, and particularly of the solvent glands, gizzards, and intestines in the *cassuarius emu*, a native of Japan, the *rhea Americana*, a native of South America, and the *struthio camelus* of Africa, that the gizzard becomes more and more fitted to economize the food as the country to which the bird belongs becomes less fertile, and that the extension of the lower intestines and cœca warrants us in believing that the processes carried on in them render the undigested food subservient to the animal's support. See *Phil. Trans.* 1813.

§ 98. In most birds, the stomach lies at the upper* part of the abdomen, that is, close to the spine, and rests in a manner on a stratum of intestines; in the *cuckoo*, however, it lies below. This peculiarity does not belong exclusively to that curious bird,† for I have found it in the *ramphastos*, and the *corvus caryocatactes* (*the nut-cracker*).

§ 99. The structure of the stomach differs most widely in the different orders and genera of this class. It appears merely as a thin membranous bag in several of those which feed on flesh and insects, when compared with the thick, muscular globes of the granivorous genera. But there are both many intermediate links‡ between these extremes, and at the same time considerable analogies in the structures, which are apparently the most opposite. This is particularly observable in the course of the muscular fibres,§ and in the callous structure and appearance of the internal coat,‖ in which points many membranous stomachs have a great resemblance to those of the *gallinæ*.

§ 100. Both parts, but particularly the muscular, are very strong in the gizzard (*ventriculus bulbosus*) of granivorous birds.* We find here, instead of a muscular coat, four immensely thick and powerful muscles; viz., a large hemispherical pair at the sides, (*laterales*) and two smaller ones (*intermedii*) at the two ends of the cavity; all the four are distinguished, both by the unparalleled firmness of their texture,† and by their peculiar colour, from all the other muscles of the body.

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* See § 41, note.

† Herissant thought this circumstance peculiar to the *cuckoo*; and supposed that it furnished an explanation why that bird does not incubate. *Mém. de l'Acad. des Sc.* 1755.

‡ Haller has collected a number of these in his *Element. Physiolog.* tom. vii. p. 115.

§ Duverney, *Œuvres Anatomiques*, tom. ii. p. 447.

‖ Wepfer, *Cicutæ Aquaticæ Historia et Noxæ*, p. 174. This is, on the whole, a most instructive work.

The internal callous coat must be considered as a true *epidermis,* since, like that part, it becomes gradually thicker from pressure and rubbing.‡ It forms folds and depressions towards the cavity of the stomach, and these irregularities are adapted to each other on the opposed surfaces. The cavity of this curious stomach is comparatively small and narrow; its lower orifice is placed very near the upper. Every part of the organ is, indeed, calculated for producing very powerful trituration. The numerous experiments which Reaumur performed, in order to determine the extent of this triturative power, are universally known. There are two curious observations on this subject less generally known. Felix Plater found an *onyx,* which had been swallowed by a hen, to be diminished by one-fourth in four days; and a *louis d'or* lost in this way sixteen grains of its weight.§ The end and use of swallowing stones with the food, the well-known instinctive practice of granivorous birds, have been very differently explained. Cæsalpinus considered it rather as a medicine than as a common assistance to digestion; Boerhaave, as an absorbent for the acid of the stomach; Redi, as a substitute for teeth. According to Whytt, it is a mechanical irritation, adapted to the callous and insensible nature of the coats of the stomach. Spallanzani rejected all supposition of design or object, and thought that the stones were swallowed from mere stupidity. I think there is not much sagacity to be discovered in this opinion, when we consider that these stones are so essential to the due digestion of the corn, that birds grow lean without them, although they may be most copiously supplied with food. This paradoxical opinion has, however, been already refuted by Hunter and Fordyce.* The use of swallowing these stones seems to me to consist in this, that they kill the grain, and deprive it of its vitality, which otherwise resists the action of the digestive powers. Thus it has been found, that if the oats and barley given to horses, are previously killed by heating, the animal only requires half the quantity, and yet thrives equally.

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* J. C. Peyer, *Anatome Ventriculi Gallinacei,* in his *Exercit. de Glandulis Intestinor.* Scafhaus. 1677, 8.

† W. G. Muys *De Carnis Musculosæ Structura.* Leid. 1741, 4to. tab. 1.

‡ Monro's *Essay on Comparative Anatomy.*

§ See Swammerdam, *Biblia Naturæ,* p. 168.

AMPHIBIA.

§ 101. The capacious œsophagus of the turtle has a very striking peculiarity in its structure; its internal coat is beset with innumerable large, firm, and pointed processes † of a white colour. Their points are all directed towards the stomach, and they probably serve to prevent the return of the food, which can only enter the stomach gradually.

§ 102. The œsophagus of the *crocodile* is of the funnel shape; the stomach of the animal resembles, although not very closely, that of the granivorous birds, in the nearness of its two apertures and the thickness of its coats.

§ 103. The stomach of serpents can hardly be distinguished from the œsophagus, except that it is somewhat larger. It is very short when compared with the great length of that tube.

Reptiles resemble birds in having their nostrils terminated by two longitudinal slits on the palate, and in the want of the velum palati and epiglottis.

The œsophagus of the serpent kind is of immense magnitude; for these reptiles swallow animals larger than themselves, which are retained for a considerable time in the tube and descend into the stomach by degrees, where they are slowly subjected to the action of the gastric juice. The whole process sometimes occupies many days, or even weeks.

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* See J. Hunter's *Animal Economy*, p. 155; and G. Fordyce *on Digestion*, p. 23.

† Ruysch, *Thesaurus Anatomicus*, 8vo. tab. 2.

FISHES.

§ 104. The œsophagus is short in most fishes; but this character is not universal, as Aristotle supposed;[*] nor is a long œsophagus peculiar to fishes of an elongated form. The large stomach of the *tetrodon hispidus* is particularly worthy of notice, for the animal can fill it in case of necessity with air, and change its naturally long form into a spherical one.[†]

From the peculiar formation of the nose of fishes, and from their respiring by means of gills, their fauces have no connexion with any nasal cavity, or glottis.

The œsophagus is of great width in fishes, and is distinguished with difficulty in many cases from the stomach. These animals swallow their food whole, without subjecting it to any mastication; and, if the stomach will not hold the whole, a part remains in the œsophagus, until that which has descended lower is digested. The alimentary canal is generally very short; sometimes extending straight from the mouth to the anus with very little dilatation, as in the lamprey (*petromyzon marinus*).

§ 105. The size and form of the stomach vary[‡] very considerably in this class. Its coats are thin in most fishes, but in some they are very thick and muscular,[§] and have a callous internal covering; still, however, the resemblance between these and the stomachs of granivorous birds is very remote.

INSECTS.

§ 106. I have already observed, on another occasion,[||] that the business of nutrition in insects does not seem to have for its object the mere preservation of the individual, as in most red-blooded animals; but chiefly the consumption of organized matter; which will appear clearly, from considering the structure of their alimentary canal.* In most of those which are subject to a metamorphosis, the stomach, in the larva state, is of a great size, in comparison with the short intestinal canal: while those, on the contrary, which take little or no nourishment in their perfect state, have this organ remarkably diminished, and as it were contracted.†

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[*] See Fabricius ab Aquapendente, p. 101 of the edition quoted above.

[†] S. Geoffroy St. Hilaire, in his *Descr. de l'Egypte Hist. Naturelle.*

[‡] Representations of the stomach of several fishes may be seen in the 2d vol. of Collins's *System of Anatomy*. Lond. 1685; and in the *Mémoires presentés à l'Acad. des Sc.* by Vicq d'Azyr.

[§] Rondelet, p. 70.

In the *Handbuch der Naturgeschichte*, (*Manual of Natural History*) p. 298; or p. 172 of Mr. Gore's excellent translation of this work.

§ 107. Our limits will allow us to take but little notice here of the endless varieties and peculiarities of internal structure, which occur in the different genera and species of this multiform class of animals. We shall therefore only bestow two words on those of the œsophagus and stomach. In several cases the commencement and termination of the alimentary canal, the œsophagus, and rectum, are surrounded by an annular portion of the spinal marrow.‡

In the earwig *(forficula auricularia)* the upper orifice of the stomach is furnished with two rows of teeth.§

In some of the *grylli* (grasshoppers) the stomach itself is small, but the œsophagus much larger.

In some species of that genus, particularly in the *gryllus gryllotalpa*, the stomach consists of three or four vesicular portions,* which have been compared with the stomachs of the ruminating mammalia.†

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* Ramdohr *Uber die Verdauungswerkzeuge der Insecten.* Halle, 1811.

† Compare, for instance, the stomach of the larva of the *papilio urticæ* with that of the perfect *butterfly*, in Swammerdam, *Biblia Naturæ*, tab. 34, fig. 4, and tab. 36, fig. 1; and particularly the whole series of changes which takes place in the *pass. brassicæ,* in Herold's *Entwickelungsgechichte Geschichte der Schmetterlinge.* Marb. 1815, 4, tab. 3, fig. 1-12.

‡ There are several delineations of the stomach in the different orders of this class, viz. that of the *scarabæus nasicornis,* in Swammerdam, tab. 27. Of the *earth-beetle,* in Rösel, vol. ii. tab. 8. Of the stag-beetle, (*lucanus cervus*) ibid. tab. 9. Of the *earwig,* in C. F. Posselt, *Tentamina circa Anatomiam forficulæ auriculariæ.* Jen. 1800, 4to. fig. 26. Of the *gryllus verrucivoras,* in Rösel, vol. ii. tab. 9. Of the *silkworm,* in Malpighi, *De Bombyce,* 1669, 4to.; in Rösel, vol. iii. tab. 9; and Bibiena, in the *Comment. Instit. Bonon.* tom. v. part 1, tab. 2 and 3. Of the *cossus,* in Lyonet's chef d'œuvre, *Anatomie de la Chenille,* &c. Of the *ephemera horaria,* in Swammerdam, tab. 15. Of the larva of the *musca chamæleon,* ibid. tab. 41. Of the *musca putris,* ibid. tab. 43. Of the *louse,* ibid. tab. 2.

§ Posselt, in the work above quoted, p. 27, fig. 27.

We have already (§ 1) mentioned the stomach of the *lobster*, and some other species of the genus *cancer* :‡ which is provided with several portions of bone. It contains also three teeth, which, together with the stomach itself, are annually reproduced, at least in the *craw-fish* (*cancer astacus*).

The crustacea, and some insects, are furnished with organs of mastication of similar structure. Their mouth is formed of two or more pairs of jaws placed laterally. These move from without inwards, and *vice versâ*, whereas those of red-blooded animals move from above downwards, and back again. The parts, which are termed the lips of insects, are two bodies ; of which one is placed above or in front of the jaws, and the other below or behind them. The palpi or feelers are articulated to the jaws. All insects, which have jaws, possess the power of masticating hard animal and vegetable substances ; for these parts are of a firm horny texture, and in many cases are very large, when compared with the size of the animal.

The locusts, (*grylli*) the dragon-fly, (*libellula*) the *beetles*, and particularly the *lucanus cervus*, or stag beetle, and the *staphylinus maxillosus*, are examples in which the jaws are very large and manifest, and often possess denticulated edges. All the genera of the following orders have jaws ; viz. the *coleoptera*, *orthoptera*, *neuroptera*, and *hymenoptera*. The insects of the remaining orders derive their nourishment chiefly from liquids ; which they get either from animal or vegetable substances by means of a spiral and tubular tongue, or a soft proboscis, (as in the *lepidoptera*) with a broad opening, admitting of extension and retraction, (the *hemiptera*) or a horny pointed tube, containing sharp bristly bodies internally (the *diptera* and *aptera*).

The stomach of the *bee* is a transparent membranous bag, in which the nectar of the flowers is elaborated and converted into honey. The animal vomits it up from this reservoir, and deposits it in the hive.

The stomach of the *crab* and *lobster* is a very singular organ. It is formed on a bony apparatus, in short a species of skeleton ; and does not therefore collapse when empty. To certain parts of this bony structure, round the pylorus, the teeth are affixed. Their substance is extremely hard, and their margin is serrated or denticulated : as they surround the tube, near the pylorus, nothing can pass that opening, without being perfectly comminuted. These bones and teeth are moved by peculiar muscles.

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* Cuvier, in the *Mémoires de la Société d'Hist. Nat. de Paris*, an 7, tab. 4.

† Swammerdam, *Algem. Verhandel. van de Bloedeloose Dierkens.* Utrecht, 1769, 4to.; and G. H. Velschii, *Hecatostea Obs.* Aug. Vind. 1675, 4to. p. 71.

‡ See Rösel, vol. iii. tab. 58 ; and Fr. Succon. *Myologiæ insectorum Specimen*, Heidelb. 1813.

VERMES.

§ 108. We can only select a few instances,* as examples of this class, which includes a great number of creatures, differing widely from each other.

The *aphrodite aculeata,* (sea-mouse) which is well-known on account of its beautiful colours, possesses a very remarkable stomach. The form and size of the viscus resemble those of a date, while in strength and compactness of texture it approaches to that of granivorous birds.†

The œsophagus is expanded into a *crop* in many *testacea,* particularly among the *bivalves;* and it is covered internally with numerous small teeth.‡

The powerful stomach of the *bulla lignaria* contains three hard calcareous shells, by which the animal is enabled to bruise and masticate the other testacea, on which it feeds.§ This stomach was lately taken by some naturalists for a peculiar genus, of an entirely new order of *three-shelled testacea.*

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* The following zootomists have given us representations of the stomach, in the different orders of *vermes,* viz. Tyson, of the round worm, (*lumbricus teres, ascaris lumbricoides*) in the *Philos. Trans.* vol. xiii. No. 147; which may be compared with Werner, *Vermium Intestin. Expositio.* Lips. 1782, tab. 7. Willis, of the *earth-worm,* tab. 4; also Vandelli, *Diss. de Aponi Thermis,* &c. Patav. 1758, 8vo. Morand, of the leech, in the *Mém. de l'Acad. des Sc.* an 1739. As well as Bibiena, in the *Comm. Instit. Bonon.* tom. vii. p. 102. Johnson *on the medicinal leech.* Lond. 1816, p. 124; and Home's *Lectures on comparative Anatomy,* tab. 70. Of the *slug,* Swammerdam, tab. 9. Of the *cuttle-fish,* ibid. tab. 51. Also Monro, *On the Physiology of Fishes,* tab. 31. Of the different species of *mollusca.* Cuvier, *Mémoires sur les Mollusques.* Paris, 1817. Leue *De Pleurobranchæa nono Molluscorum genere.* Hal. 1813. Poli, of several testacea, in his *Testacea utriusque Siciliæ,* viz. the *pholas dactylus,* tom. i. tab. 7; the *tellina planata,* tom. i. p. 14. *Mactra Neapolitana,* tom. ii. tab. 19; the *venus chione,* tab. 20. Of the snails, Wohnlich *De Helice pomatia.* Wirceb. 1813. Stiebal, *Limnei Stagnalis Anatome.* Götting. 1815. Feider *De Halyotidum structura.* Hal. 1814.

† See Pallas, *Miscellaneo Zoologica,* tab. 7.

‡ For instance, in the *chiton cinereus,* see Poli, tom. i. tab. 3. Compare also the œsophagus of the *cuttle-fish,* which is furnished with teeth in the same manner. See Turberville Needham's *Nouvelles Observations Microscopiques,* tab. iii.

§ Humphrey in the *Trans. of the Linnæan Society,* vol. ii. p. 15. Draparnaud in the *Journal de Physique,* tom. vii. p. 146.

In most of the proper *mollusca,* the stomach is of a simple membranous structure, and of very different comparative magnitudes. I have found it very large in the *scyllæa pelagicum.* It occupies the greatest part of the body in the *leech,* and is divided internally by means of ten imperfect fleshy partitions, into somewhat separate portions.

Lastly the armed polypes (*hydræ*) and other similar *zoophytes,* can hardly be considered as any thing more than a mere stomach, having its openings furnished with tentacula.

In those *mollusca,* which possess jaws, these parts are fixed in the flesh of the animal, as there is no head to which they can be articulated. They are two in number in the *cuttle-fish,* are composed of a horny substance, and resemble exactly the bill of a parrot. They are placed in the centre of the lower part of the body, and are surrounded by the tentacula, which enable the animal to attach itself to any objects. By means of these parts, the shell-fish, which are taken for food are completely triturated. The *common snail* and *slug* have a single jaw, semilunar in its form, and denticulated. The *tritonia* has two jaws, which act like the blades of a pair of scissars. The other *mollusca* possess no organs of this kind ; but have, in some instances, a sort of proboscis ; as the *buccinum, murex, voluta, doris, scyllæa,* &c.

In the *worms,* properly so called, there are sometimes hard parts forming a kind of jaws or teeth. Thus in the *nereis,* the mouth possesses several calcareous pieces. The *aphrodite* (*sea-mouse*) has a proboscis, furnished with four teeth, which it can extend and retract at pleasure. Within the mouth of the *leech* are three semi-circular projecting bodies, with a sharp denticulated edge ; by this apparatus the animal inflicts its wound of the well-known peculiar form in the skin.

The teeth of the *echinus* (sea-hedgehog) are of a very singular arrangement ; a round opening is left in the shell for the entrance of the food ; a bony structure, on which five teeth are placed, fills up this aperture ; and as these parts are moved by numerous muscles, they form a very complete organ of mastication.

The stomach of the *vermes* is, in general, a membranous bag ; but in some cases its structure is more complicated. In addition to the instances mentioned by the author, we may observe that the *helix stagnalis,* and the *onchidia* have gizzards. The *aplysia* has three strong muscular stomachs, provided with pyramidal bony processes. This structure, together with that of the *bulla lignaria,* and of the *lobster* and *crab,* presents a new analogy, as Cuvier has observed, between the membranes of the intestines, and the integuments of the body. This is particularly strengthened by the annual shedding of the lobster's teeth, when its crustaceous covering falls off.

CHAPTER VII.

ON THE INTESTINAL CANAL.

MAMMALIA.

§ 109. The intestinal canal (which is the most common part in the whole animal kingdom after the stomach), is distinguished in this class by two peculiarities, which depend on the mode of nutrition. It is comparatively shorter in *carnivorous animals*, and there is also in these less difference to external appearance between the small and the large intestine, than in the *herbivora*. Yet these rules are not without their exceptions. For the *seal* has very long, and the *sloth* very short intestines; the *badger*, which is not a proper carnivorous animal, and several true *herbivora*, as, for instance, the *rell-mouse*, (*glis esculentus*) have no distinction between the large and small intestine.

It is worthy of notice how the calibre of the intestines and the strength or thickness of their tunic bear no definite proportions to each other. Hence the small intestines of a full grown *seal*, which are very long, and of the size of the little finger in thickness, have much stronger tunics than those of the *opossum*, the calibre of which is equal to the size of the thumb.*

In considering the proportionate lengths of the intestinal canal, and the relation which these bear to the kind of food on which the animal subsists, many circumstances must be taken into the account, besides the mere measure of the intestine. Valvular projections of the internal membrane, dilatations of particular parts of the canal, and a large general diameter, compensate for shortness of the intestine, and *vice versa*. The structure of the stomach must also be considered; as, whether it is formed of more than one cavity; whether the œsophagus and intestine communicate with it in such a manner as to favour a speedy transmission of the food; or, whether there are *culs de sac,* which retain the aliment for a long time in the cavity. The formation of the jaws and teeth, and the more or less perfect trituration and comminution which the food experiences in the mouth, must likewise be viewed in connexion with the length and structure of the alimentary canal.

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* Vide Pallas, *Novæ Species quadrupedum e Glirium ordine.* Erlang. 1778-4.

The whole length of the canal is greater in the *mammalia* than in the other classes. It diminishes successively, as we trace it in *birds, reptiles,* and *fishes,* being shorter than the body in some of the latter animals, which is never the case in the three first classes.

In omnivorous animals, the length of the canal holds a middle rank between those which feed on flesh, and such as take vegetable food. Thus, in the *rat,* its proportion to the body is as eight to one; in the *pig* thirteen to one; in *man* six or seven to one. The diminution in length, in the latter case, is compensated by other circumstances, viz. the numerous valvulæ conniventes, and the preparation which the food undergoes by the art of cookery.

In carnivorous animals every circumstance concurs to accelerate the passage of the alimentary matter. It receives no mastication; it is retained for a very short time in the stomach; the intestine has no folds or valves; it is small in diameter; and the whole canal, when compared to the body, is extremely short, being three or five to one.

The ruminating animals present the opposite structure. The food undergoes a double mastication, and passes through the various cavities of a complicated stomach. The intestines are very long; twenty-seven times the length of the body in the *ram.* Hence the large intestines are not dilated, or cellular; nor is there a cœcum. The *solipeda* have not such a length of canal, nor is their stomach complicated; but the large intestines are enormous, and dilated into sacculi: and the cœcum is of a vast size; equal, indeed, to the stomach. The *rodentia,* which live on vegetables, have a very large cœcum, and a canal twelve or sixteen times as long as the body. In the *rat,* which can take animal as well as vegetable food, the canal is shorter than in the other *rodentia.*

There are some exceptions to the rule which we have just mentioned respecting the length of the canal in carnivorous and herbivorous animals. The *seal,* which takes animal food, has very long intestines: the *sea-otter* resembles it in this respect, and differs therein most remarkably from the common otter, which resembles other carnivorous animals in the shortness of its intestinal tube. The length of canal in the former is twelve times that of the animal; and only three times and a quarter in the latter. (Home, in the *Philos. Trans.* 1799, part 2.) *Whales* have likewise a longer canal than other carnivorous mammalia; their stomach is complicated, and the intestine has longitudinal folds. It seems, therefore, that a considerable length of intestinal canal is found in all mammalia which live much in the water, although they are carnivorous.

The *plantigrade* animals, which have carnivorous teeth, but feed equally well on vegetables, have a long canal; but it is very narrow, and possesses no cœcum, nor distinction of large intestine.

A species of bat (*vespertilio noctula*), seems to have the shortest intestinal canal of any mammalia: it is only twice the length of the animal's body. On the contrary, the *roussette* (*vesp. vampyrus*, Linn. *v. caninus*, Blum.) which lives entirely on vegetables, has it seven times as long.

A remarkable difference is observed in the length of the canal between the wild and domesticated breeds of the same species. In the *wild boar* the intestines are to the body as nine to one; in the tame animal these proportions are as thirteen to one. In the *domestic cat*, five to one; in the *wild cat*, three to one. In the *bull*, twenty-two to one; in the *buffalo*, twelve to one. They are, on the contrary, longer in the wild than in the tame rabbit; the proportions in the former being eleven, and in the latter nine to one.

The proportion of the intestinal canal to the length of the body in *birds*, is as two, three, four, or five to one. It is not always longest and largest in the graminivorous species, as many piscivorous birds have it equally long.

It is hardly twice the length of the body in many *reptiles;* and not so much in the *frog*, although it is nine times as long as the space between the mouth and the anus in the *tadpole*.

The alimentary canal of some fishes is continued straight from the mouth to the anus, and does not therefore equal the length of the body. The *lamprey*, *skate*, and *shark*, are thus circumstanced.

§ 110. The valvulæ conniventes of the small intestine are more faintly marked in most mammalia than in man; in some, indeed, they do not exist at all, and this happens both in carnivorous and herbivorous animals. In the *cetacea*, on the contrary, the internal surface of the intestines has longitudinal folds of a zig-zag appearance.

The possession of a villous coat for the absorption of the chyle constantly distinguishes the small from the large intestine, which seems to be merely destined for the reception of the fæces. The villi are remarkably long and numerous in the bear.*

The Fallopian valve (*valvula coli*) is wanting in a few animals only of this class, as, for instance, in the *hedgehog*,† *ornithorhynchus*, and *racoon*.

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* On the structure of this coat in several species of the four classes of red-blooded animals, see Roun. Ad. Hedwig, *Disquisitio ampullulanium* Lieberkühii. Lips. 1797-4; Rudolphi's *Anatomische physiologische Abhandlungen;* and Meckel's *Archiv V.* B. 1819.

† Roederer gives an accurate description of this valve in our domestic animals, *De Valvula coli*. Argent. 1768, 4to. p. 46.

§ 111. There is great variety with respect to the cœcum in this order, even in the different species of the same genus. Many, particularly of the *carnivora,* have none; it is also wanting in some herbivora, as the *rell-mouse.* In others of the latter description it is often of enormous size. Thus in the *hare* and *rabbit* it is longer than the whole animal, and furnished internally with a peculiar spiral valve. The *marmot of the cape,* (*hyrax capensis*) has first a large cœcum, and then, further on, two other conical blind appendices.*

The *appendicula vermiformis* is wanting in many mammalia; even in some of the *simiæ,* as the *silvanus,* &c.

Most of the animals which have a vertebral column, have the intestine divided into two parts; viz. the large and small. The latter is commonly the longest, smallest in its diameter, and villous on its internal surface. The former is often thicker in its coats, and very rarely villous. In those mammalia which have this distinction, the separation is marked by one or more appendages, which have the name of *cæcum* when large, of *vermiform appendix* when slender. *Man,* the *orang-outang,* and the *phascolome,* (a species of rat having an abdominal pouch, from New Holland) are the only animals which have both cœcum and appendix. The *ornithorhynchus hystrix* has an appendix only; and most other mammalia have only a cœcum. All the *simiæ,* except the *orang-outang,* have a cœcum, like that of man, but want the appendix vermiformis.

Several possess neither cœcum nor appendix, as the *edentata,* (except the proper *ant-eaters*); the *tardigrada,* the *bats,* the *plantigrada,* except the *ichneumon,* the *mustelæ,* and the *myoxi* (*dormice*); and the *cetacea.*

A *valvula coli* shews the distinction between the large and small intestine, where the cœcum is wanting; as in the *sloth* and *armadillo.* When this distinction does not exist, the large intestine is characterized by the want of villi, by a greater thickness of its coats, and particularly by a strong layer of longitudinal muscular fibres.

In animals, which have a cœcum, this part appears to be merely a prolongation of the large intestine below the termination of the small. Yet in some cases, the large intestine retains only for a short space the same structure which the cœcum possessed, as in the flying *lemur,* (*galeopithecus*) the *opossum,* most of the *rodentia* and *ruminantia.* In the herbivorous mammalia the cœcum is generally large and cellular; and it is even so in omnivorous animals, as in *man,* in the genus *simia,* and *lemur.* In the *ruminantia,* where the stomach is very complicated, the cœcum is of a moderate size, and uniform. It is large and cellular in the *flying lemur* and *opossum*, which are supposed to live much on animal substances.

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* Pallas, *Spicilegia Zoologica,* tom. ii. tab. 3, fig. 7, 8.

The cœcum of the true carnivorous mammalia is constantly small, and uniform in its cavity; and the rest of the large intestine has the same characters. The large intestine of the herbivora is cellular, excepting the ruminantia and some of the rodentia.

It may therefore be stated as a general rule, that the existence of a large cœcum shews that the animal feeds on vegetables; and that carnivorous mammalia have either none, or a very small one.

The *ornithorhynchus paradoxus* and *hystrix* have the end of the rectum forming a cloaca, as in birds. The urinary bladder opens into this part. The penis of the male is contained within it; and the horns of the uterus open into it in the female. Home in the *Philos. Trans.* 1802, pt. 1, of the *ornithorhynchus paradoxus*, pt. 2, of the *ornithorhynchus hystrix.*

§ 112. In most herbivorous animals of this class, the colon is large, long, and divided into cellular compartments. This is remarkably the case in the *elephant* and *horse*. The large intestine of the latter is twenty-four feet long; while, on the contrary, in a moderate sized dog it is about six or eight inches. The rectum of the latter has strong transverse folds which contract it, and render the evacuation of the fæces difficult.

In a few instances, as in the *beaver* and *sloth*, but most remarkably in the *ornithorhynchus*, the rectum and urethra have a common termination, which may be compared to the cloaca of birds.

As we have spoken above of the *bezoars* and other concretions formed in the stomach, we must here take notice of the intestinal stones which occasionally occur in horses, and of the valuable fæcal concretions of the pike-headed whale or *cachalot* (*physeter macrocephalus*).

The former are commonly of a yellowish grey colour; of a globular form, shining externally, but of a dead and earthy appearance; when broken, not very hard; and in their average size about equal to a billiard ball, although they have been found as large as a man's head: all these external characters vary indeed considerably. The most remarkable circumstance relating to them is their composition; according to Fourcroy's and Klaproth's Analysis, they consist in the proportion of one half of phosphate of magnesia. They are often found in millers' horses, which have been fed for a long time with bran and mill-dust; there is usually only one, but sometimes more; they are most frequent in the colon, and have very seldom been found in the stomach. They are not discovered in general until the death of the animal; but I find an instance, in the *Epistolæ de Re Numismatica ad Z. Goezium*, of a horse, which voided a stone of the above-mentioned kind, as large as a hen's egg, every month with his fæces.

A species of globular concretions, very different from these intestinal stones, is occasionally found in the colon and cœcum of the *horse*. It is composed of fine vegetable fibres, and resembles, on the first view, the balls of the *chamois*. Hence Lafosse, who has described and delineated them, calls them *ægagropilæ*, by way of distinction from the true intestinal stones, which he terms *bezoar equinum*.* Like the balls of the *chamois*, they are much lighter than intestinal stones; and two of them are not unfrequently found together, one being inclosed within the other.

The fæcal indurations of the *cachalot* form the valuable substance known by the name of *ambergris*, which was formerly considered as an animal excrement, but has been supposed latterly by some to be a fossile substance, by others to be a vegetable resin: its animal origin is now placed beyond all doubt. Sir Joseph Banks informed me, that according to what he could learn from the English South-Sea whalers, the fæces of the *cachalot*, which are nearly fluid in a healthy state, are hardened into this ambergris by a kind of constipation; hence it is only found in weak and exhausted animals, and the firmest and most valuable comes from such as seem to have died of the complaint which it has occasioned.

BIRDS.

§ 113. The alimentary canal in birds is much shorter than in the mammalia; it is also generally shorter in carnivorous birds than in such as derive their food from the vegetable kingdom. There is hardly any perceptible external difference between the large and small intestine; indeed, the commencement of the canal is often larger than the termination.

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* See his *Cours d'Hippiatrique*, p. 158, tab. 51.

§ 114. Most birds have two cœca, which are of considerable length in some species of the gallinaceous and aquatic tribes. They are characterized in the *ostrich,*[*] by a remarkable spiral valve. Some few aquatic birds have only a single cœcum; and some, particularly among the birds of prey, want it entirely.

§ 115. The rectum ends in a part called the cloaca, which is an expanded portion, containing the termination of the ureters, the genital organs, and the *bursa Fabricii.* This latter part varies in form in the different species, being oval or elongated, &c.; it is largest in young birds, and is so contracted in older ones, that it will hardly hold a millet-seed in an old cock.[†] In the *ostrich* the cloaca forms a large spherical bladder; a similar structure is observed in the *goshawk* and in the *grey heron.*

The *bursa Fabricii* is an oval membranous bag, situated at the upper or back part of the cloaca, into which it opens by a slit-shaped aperture. Its size is proportionate to that of the animal; being one inch and a quarter long in the *goose,* and half an inch broad; and about a quarter of an inch long in the *sparrow.* According to the accurate observations of Mr. Macartney, its coats contain numerous glandular bodies which furnish a mucous secretion. (Article Birds in Rees's Cyclopedia.)

AMPHIBIA.

§ 116. We shall take only one species of each of the two chief divisions of this class by way of examples.

The intestinal canal of the hawks-bill turtle (*testudo caretta*) is five times as long as the whole animal; the small intestine is larger than the short portion of large intestine. Both portions have longitudinal folds internally, and are covered with an abundance of mucus, which is the case in the whole class.

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[*] See Valisnieri *Notomia dello Struzzo,* tab. 2, fig. 1, 2.

[†] S. Collins's *System of Anatomy,* vol. ii. tab. 73.

I found these folds so large and numerous in the rectum, that a transverse section of the gut presented the appearance of a broad radiated ring.

That portion of the small intestine which corresponds to the jejunum was beset, in the animal which I dissected, with innumerable small processes, like the *appendiculæ epiploicæ*, which are occasionally found in some mammalia.

§ 117. In the *ringed-snake*, (*coluber natrix*) the whole length of the intestinal canal does not equal that of the animal. The small intestine forms a very considerable *fallopian valve*, by a prolongation at its entrance into the large. The termination of the small, as well as the large intestine, the stomach, and the œsophagus (which is one third of the length of the whole animal) have longitudinal folds* internally.

FISHES.

§ 118. The intestinal canal of this class, with a very few exceptions, is extremely short. In some, as the *torpedo*,† it is only half as long as the stomach. However, the passage of the chyle, and afterwards of the fæces, through the intestine, is lengthened in this, and some other cartilaginous fishes, by a spiral valve.‡

In the structure and formation of the coats of the intestinal canal there are not many differences in the *mammalia*. True *valvulæ conniventes* seem peculiar to *man* and the *monkeys*. But the internal surface of the intestine is always villous, and generally deserves that appellation more than in the human subject. Some of the *carnivora*, as the *dog*, have very long villi, and this class has, in general, more muscular intestines. A considerable number of mucous glands is found near their cœcum, when they have one. But the *seal* has these glands in greatest number, and most distinct. They form, in that animal, a regular and unbroken series through the whole length of the lower portion of the small intestine, and are very visible on account of their colour.

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* See Charas, *Nouvelles Experiences sur la Vipère*. Par. 1672, 8vo.; and Tyson's *Anatomy of a Rattlesnake*. Philos. Trans. vol. xiii. No. 144.

† Lorenzini, *Osservazioni intorno alla Torpedine*. Fior. 1678, 4to. tab. 2.

‡ It is delineated from another species of *ray* by Swammerdam, in the 4th edition of Bartholin's *Anatomy*. Lugd. Bat. 1673, p. 297 ; which contains much valuable information in zootomy. Perrault has represented it in a *shark*, *Essais de Physique*, vol. iii.

The villous coat of the intestine forms numerous oblong processes in the *rhinoceros.* (Philos. Trans. 1801, pt. 1.)

The villi in the small intestine of birds are remarkably long, numerous, and elegant. They are most distinct and clearly developed in the *graminivorous* birds. In the *ostrich* they are rather flat thin laminæ than villi, but at the same time long and numerous, so as to present a very elegant structure. The large intestine of birds is uniform on its surface, but the *ostrich* presents a very remarkable deviation, for its large intestines, which are very long, have numerous transverse folds like the valvulæ conniventes of man.

The intestine of the *turtle* is covered with innumerable thin longitudinal processes, lying close together, and increasing the surface of the gut to a vast extent. These are most numerous in the upper part of the intestine, and gradually diminish in number below, until they cease altogether. In this respect they resemble the valvulæ conniventes of man, and the villi of all animals. For these structures are always most distinct at the commencement of the canal, where absorption of the chyle goes on to the greatest extent. As the alimentary matter becomes deprived more and more of its nutritious parts, as it descends in the intestine, a less complicated apparatus for absorption exists in the lower part of the canal, and is sufficient for taking up the small remains of really nutritious parts. This circumstance is illustrated in the longitudinal folds of the cetaceous animals. At the commencement of the intestine there are four or five of these; at different distances we meet with four, three, two, one, and lastly the surface is completely uniform.

§ 119. The *appendices pyloricæ* (which are found in all fishes, with a very few exceptions, as the *pike*) sometimes open at the lower orifice of the stomach, but generally at the commencement of the intestinal canal, and secrete a fluid, which seems to have considerable influence on the business of digestion and chylification,* which is performed in these animals in a very short time. They have generally the appearance of small blind appendices,† and their number varies in the different species, from one to several hundred. In some cartilaginous fishes they are as it were consolidated into a glandular body,* which has been compared to the pancreas of warm-blooded animals.

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* The leading work on this subject is very rare, *Pars altera Observ. Anat. Collegii privati.* Amstelod.; which was produced almost entirely by Swammerdam.

† In some, as the *burbot,* they appear almost like a finger. Hence, the part has been called the *burbot*'s hand or foot. See Chr. Encelius *De Re Metallica*, Francof. 1551, p. 241; which contains, I believe, the first delineation of the part.

INSECTS.

§ 120. Similar blind appendices (*vasa varicosa* of Swammerdam) are found on the short alimentary canal of several insects, which is particularly distinguished from that of red-blooded animals by the want of mesentery.† Some zootomists have considered these appendices as small intestines, others as biliary ducts, and others as lacteal vessels.

VERMES.

§ 121. Several *mollusca* have these appendices on both sides of their short intestinal tube, as the *aphrodite aculeata*. Those *testacea* which remain fixed in one situation, have a shorter and more simple intestinal canal than those which have the power of locomotion. The rectum, according to Poli, passes directly through the heart in most of the bivalves. In the slug, (*limax*) as well as in the similar animal, which inhabits a shell, (*helix*) the rectum opens on the front of the *limbus,* close to the air-hole. The *leech* can hardly be said to possess an intestine; yet it has an anus at the end of the tail, from which some little fæcal matter is discharged, most of this being evacuated by the mouth. The *armed polypes* have no opening of this kind.

As the part of his work which the author has devoted to the alimentary canal of the lower orders of animals is very short, and as the subject is interesting in many points of view, it seems right to subjoin a somewhat more ample account.

The simple globular *hydatid,* which is frequently found in the different viscera both of man and quadrupeds, has been supposed by some to be an animal consisting entirely of a stomach. Doubts, however, have lately been raised, whether this be really an animal. The reader, who wishes to see the arguments on both sides of the question, may consult the "*Observations on the Manner in which Hydatids grow and multiply in the Human Body*," by John Hunter, M.D. in the 1st vol. of the *Transactions of a Society for the improvement of Medical and Chirurgical Knowledge;* and the note to the 83d paragraph of this work. Even if it were allowed that these bags are animals, it does not follow that their cavity is a stomach; and the attachment of the young to the sides would rather justify us in considering it as the organ of generation.

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* The consequences which may be drawn from this circumstance towards the elucidation of the business of secretion, have been already pointed out in my *Instit. Physiol.* p. 401, edit. 4.

† On this subject, as well as on several of the following chapters, the references contained in the notes to the 107th and 108th paragraphs may be consulted. See also Ramdohr, *über die Vardauungswerkzeuge der Insecten.*

The *hydatid*, which is more frequently found in animals, which possesses a head and mouth like the tænia, enabling it to attach itself to parts, and which can be seen to move when placed in warm water, is generally allowed to possess an independent vitality. But whether the bags of water, which form its body, be a stomach, is certainly doubtful.

The most simple form of an alimentary cavity exists in the common fresh-water polype (*hydra*). It appears to be excavated in the substance of the body, and has a single opening, situated in the centre of the space surrounded by the tentacula. The nutritive matter soaks immediately into the body, and imparts its colour to the animal.

The large masses of gelatine, called *medusæ*, which resemble in form mushrooms, and are found floating in the sea, have a somewhat similar structure. A stomach is hollowed out in the pedicle, and vessels, commencing from its cavity, convey the nutritious fluid over the body. Sometimes the stomach has a simple opening; in other cases there are branching tentacula, on which canals commence by open orifices: these unite together to form larger tubes, and the successive union of these vessels forms at last four trunks, which open into the stomach, and convey the food into that cavity. This very singular structure constitutes a remarkable analogy to the roots of trees; and Cuvier has formed a new genus under an appellation derived from this comparison; viz., the *rhizostoma*, from ῥιζα, a root, and στομα a mouth.

The star-fish (*asterias*) has a membranous cavity in the centre of its body, communicating externally by a single opening. Two canals extend from this into each of the branches, or as they are sometimes called the fingers of the animal, where they subdivide, and form numerous blind processes.

The tape-worm (*tænia*) has a small canal running on each side of its body; the two tubes are joined together by transverse productions at each joint.

The *ascaris lumbricoides* (round-worm) has a simple canal running from one extremity of the body to the other.

The leech (*hirudo sanguisuga*, or *medicinalis*) has a short œsophagus and a very large stomach, divided by numerous membranous septa, which are perforated in the centre. It has been generally supposed that this animal has no anus; but Cuvier says that it possesses a very small one. (*Leçons d'Anat. comp.* tom. iv. p. 141; Dumeril, on the contrary, denies its existence. *Zoologie Anatomique*, p. 298.)

The common *earth-worm* (*lumbricus terrestris*) has a long canal divided by several partitions.

The *aphrodite aculeata* has an intestine running according to the length of the body, and sending off on each side several blind processes which enlarge at their termination.

In the proper *mollusca*, besides the stomach, which has been already noticed, there is an intestine, seldom of considerable length, making some turns in its course; it passes, in all the *acephalous mollusca,* through the heart.

The intestinal canal of *insects* varies very much in the different genera and species. It may be stated on the whole, that a long and complicated intestinal tube denotes that the insect feeds on vegetables; while the contrary characters indicate animal food.

Great difference is found, in some instances, between the *larva* and the perfect insect. The voracious *larvæ* of beetles (*scarabæi*) and butterflies have intestines ten times as large as the winged insects, which are produced from them.

In the *dragon-fly*, (*libellula*) which is very carnivorous, the intestine is not longer than the body. There is a small but muscular stomach.

The *orthoptera* (which class contains the locusts, &c., well known for their destructive powers) have a long and complicated alimentary apparatus. They have first a membranous stomach. This is succeeded by another cavity covered internally with scales or teeth, and possessing a very thick muscular coat; in short, a true gizzard. Round the end of this the cœcal processes are attached. There is, lastly, an intestinal canal differing in length and diameter.

The alimentary canal runs straight along the body in the *crustacea*, and is uniform in its dimensions, excepting the stomach.

CHAPTER VIII.

ON THE LIVER, SPLEEN, AND OMENTUM.

§ 122. WE may conveniently collect together, in this chapter, whatever is to be said concerning the liver, spleen, and omentum; since these parts are connected with each other in their functions.

The spleen and omentum seem to be less constantly found in the animal kingdom than the liver, and to be in a manner subservient to the latter viscus; which, on the contrary, exists in every class and order of animals that is provided with a heart and circulating system.*

MAMMALIA.

§ 123. Besides the less important variations in size, colour, division into lobes, &c., the liver of these animals is distinguished by two chief differences; first, in some genera and species it transmits all the bile immediately into the duodenum. Secondly, in several others a part of this fluid is previously collected in the gall bladder. Animals of the *horse*† and *goat* kind, and some of the *cetacea,* afford instances of the want of this receptacle.

On the contrary, in some of those which have it, there are *hepatico-cystic ducts,* which convey the bile immediately from the liver into this bladder, as in the *horned cattle*. It deserves to be remarked here, as a peculiarity of the liver of some four-footed mammalia, which live in or about the sea, namely, the *polar bear* and some *seals*, that it seems to possess some poisonous or noxious qualities when employed for food. Heemskerk's companions experienced this in the former instance at Nova Zembla; and Lord Anson's squadron in the latter, on the coast of Patagonia.

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* On the liver, in the different classes of animals, see N. Mulder *De functione hepatis, in disquisitione illius visceris nixa.* Leyd. 1818; also F. Ebeling *De pulmonum cum hepate Antagonismo.* Gotting. 1806. On the spleen, see Wilbrand, in Oken's *Isis,* 1821, vol. vi. p. 543.

† An enumeration of the mammalia, which have no gall-bladder, will be found in F. Trott *De vesiculæ felleæ defectu.* Erlang. 1822, 4to. Some have considered the large hepatic duct of the *horse* as a gall-bladder. See Sir Thomas Brown's *Pseudodoxia Epidemica,* p. 119, ed. of 1672. This might with more truth be said of the *elephant,* where the hepatic duct has a considerable expansion just at its entrance into the intestine. *Œuvres de Pierre Camper,* tom. ii. ch. 4, § 3.

In the *ox* and *sheep* the spleen is distinguished by a peculiar cellular* structure from the merely vascular texture which it possesses in other animals of this class. Perhaps this difference in texture may lead to the discovery of the true functions of this viscus, the use of which is at present unknown.†

Mammalia‡ alone possess a true and proper omentum; and the part which has been called a spleen in other animals is very different in its structure, connexions, &c. from the same viscus as it exists in this class. I quote only a single instance of the peculiar appearances of the omentum in particular species; viz. that of the *racoon*, (*ursus lotor*) which has a very remarkable structure. It is comparatively large, and consists of innumerable stripes of fat, disposed in a reticular form, and connected by an extremely delicate membrane, resembling a spider's web. I have also found it particularly large in an old lioness.

The liver of mammalia is in general divided into more numerous lobes, and the divisions are carried deeper into its substance, than in the human subject. This is particularly the case in the *carnivora*, where the divisions of the lobes extend through the whole mass. But the utility which Monro has assigned to this structure; viz. that of its allowing the parts to yield and glide on each other in the rapid motions of the animal, carries very little plausibility with it. (*Essay on comparative Anatomy*, p. 11.)

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* Stukeley *on the Spleen*, tab. 3 and 4.

The hepatico-cystic ducts, and the cellular structure of the spleen, are the more worthy of mention, as they have given rise to errors in physiology.

† On the singular pustular eruption, which sometimes appears on the spleen of hydrophobic animals, as the *dog*, *fox*, and *cat*, see Locher, *Magnum lienis in hydrophobia Momentum*. Gött. 1822. A similar conformation has been discovered by Neergaard in the *Racoon*. See his *Vergleichende Anat. der Verdauungswerkzeuge*, § 6, fig. 4.

‡ See A. G. Stosch *De omentis Mammalium, partibusque illis similibus aliorum Animalium*. Berol. 1807. A description of the spleen in many birds, amphibia, and fishes, will be found in Moreschi *della Milza in tutti gli Animali vertebrali*. Milan, 1803; also C. F. Heusinger, *über den Bau und die Verrichtung der Milz*. Thionv. 1817.

In many animals of this class, as the *horse*, the *ruminantia*, the *pachydermata*, and *whales*, the liver is not more divided than in man.

The *ductus choledochus* forms a pouch between the coats of the intestine, for receiving the pancreatic duct, in the *cat* and *elephant*.

All the *quadrumana*, *carnivora*, and *edentata* have a gall-bladder.

Many *rodentia*, particularly among the rats, want it. The *tardigrada*; the *elephant* and *rhinocĕros*, among the *pachydermata*; the genus *cervus* and *camelus* among the ruminating animals; the *solipeda*; the *trichecus* and *porpoise* also want this part. It does not exist in the *ostrich* and *parrot*, but is found in all the *reptiles*. Cuvier thinks that it belongs particularly to carnivorous animals; that it is connected with their habit of long fasting, and serves as a reservoir for the bile.

All the mammalia which want it, except the *porpoise*, are vegetable eaters; and most reptiles, which universally possess it, live on animal food. (*Leçons d'Anat. comp.* tom. iv. p. 37.)

The valvular transverse folds of the cystic duct belong only to the *simiæ*, besides the human subject.

The spleen of the *ornithorynchus hystrix* is composed of two lobes; the anterior somewhat long and thick, the posterior broader and thinner. Both run obliquely towards the right side to meet at an acute angle in the left hypochondrium. The texture is loose and spongy. See Meckel *De Ornithorhyncho paradoxo*, p. 46, Lips. 1826.

BIRDS.

§ 124. The liver is much larger in domesticated than in wild birds.* It is well-known that the gall-bladder is wanting in many species of this class, (for instance in the *pigeon*, *parrot*, &c.) and sometimes in particular individuals of a species, which commonly has it, as in the *common fowl*.

A roundish lump of fat, which covers the intestines of some aquatic birds, has been considered as an omentum.

The liver of birds is divided into two equal lobes. The hepatic duct opens separately from the cystic, and its termination is generally, but not always, preceded by one or more pancreatic ducts, and followed by that of the cystic duct.

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* B. Robinson *On the Food and Discharges of Human Bodies.* London, 1748-8, p. 97.

The fundus of the gall-bladder receives branches from the hepatic duct, but that tube sometimes unites with the cystic, as in the *duck.*

AMPHIBIA.

§ 125. The liver, in these animals, is universally of considerable size; and in some instances, as the *salamander*, of immense magnitude. I know no species in which the gall-bladder is wanting.

The yellow appendices (*ductus adiposi, appendices luteæ*) which are found in the *frog*, on either side of the spine, above the kidneys, and sometimes form one mass, sometimes are divided into several smaller portions, were considered by Malpighi as a kind of omentum.* That this resemblance is very remote, appears from several circumstances; and particularly from the constant and remarkable variations of size which occur in these parts at the pairing season.

In the *tortoise* the liver has a peculiar conformation. It is divided into two round irregular masses, of which one occupies the right hypochondrium, and the other rests on the small curvature of the stomach. Both are connected by two narrow branches of the same structure, into which the principal vessels run. In the *green lizard*, in the *geckos*, *dragons*, *iguanas*, it forms only a single mass, flat or convex below, and concave above. Its free edge in the *dragons* has two fossæ, which divide into three lobes, of which the right is prolonged into a sort of tail. In the *geckos* it has only one fossa, and the right side is also longer than the left. In the *common iguana* it extends into a long appendix. In the *crocodiles* and *chameleons* the liver has two distinct lobes. In the latter it has also a long appendix. It has but one lobe in the *serpent* tribe, in which it is long and cylindrical. There is but one also in the *salamanders*, but there are two in the *frog* genus.

FISHES.

§ 126. In many animals of this class, the short intestinal canal is surrounded, and as it were consolidated with a long liver. Some fishes, which are almost destitute of fat in the rest of their body, have an abundance of oil in the liver; as, for instance, the *skate* and *cod.* It is wanting in some few species.

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* *De Omento et Adiposis Ductibus*, Oper. tom. ii. p. 35, &c.

The spleen gradually diminishes in size from the mammalia to fishes. In the *porpoise* there are several small spleens; supplied from the arteries of the first stomach. It is always attached to the first, when there are several stomachs.

In birds it is always near the bulbus glandulosus; but does not lie constantly very close to the stomach in reptiles; as it is found in the mesentery of the *frog.* Neither is it very uniformly situated in fishes.

The size of the liver is generally very considerable; its colour is frequently yellower than in reptiles, and its divisions are as uncertain as in the three preceding classes, so that they frequently vary, even in the different species of the same genus. Its consistence is also less compact than in the three classes; hence its parenchymatous texture readily dissolves in spirits of wine, and leaves the vessels of the liver exposed. In general its divisions are few; very frequently it only forms one mass, sometimes however it has two lobes, occasionally three, but very seldom more.

It rarely happens that the different branches of the hepatic canals unite in one duct, they open successively into the gall-bladder or its canal, whence the whole of the bile is conveyed into the intestine. The diameter of the cystic duct is always much larger than that of the hepatic, but its size does not increase after its junction with the other ducts. In the rays the gall-bladder receives several very fine hepatic canals; afterwards the hepatic canal furnishes a principal branch, which comes from the middle lobe of the liver, and joins the cystic duct at a short distance from its origin. The different branches of the hepatic canal unite in the *syngnathus pelagicus* into one trunk, which joins the cystic duct. In the *tetrodons,* the hepatic canals have three principal branches, the first of which joins the gall-bladder, a little on one side of its neck, and the second and third open into the cystic duct, a little beyond its origin.

INSECTS.

§ 127. An organ secreting bile, and which may therefore be regarded as a liver, is found in such animals only of this class as have a heart and system of vessels, viz. in the genus *cancer.** We have already observed, that the blind appendices found in several others, have been considered as biliary organs.

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* Willis *De Anima Brutorum,* tab. 3. Rösel, vol. iii. tab. 58 and 59.

The large adipose substance which occupies the greatest part of the body of larvæ, and of several insects, has appeared to some zootomists to resemble the omentum.*

VERMES.

§ 128. The organs which secrete and contain the fluid of the *cuttle-fish* have been regarded as of a biliary nature. Thus, the *mytis* has been called the liver, and the *ink-bag* the gall-bladder.†

Several *testacea*, particularly among the *bivalves*, have a liver surrounding their stomach, and pouring its bile into the cavity‡ of that organ. In many snails it occupies the upper turns of the shell.§

A liver exists in all the *mollusca*, and is very large; but this class has no gall-bladder. The liver is supplied with blood from the aorta, and there is consequently no *vena portarum*.

It is a completely mistaken notion, that the black fluid of the *cuttle-fish* is its bile. The *ink-bag* is indeed found between the two lobes of the liver in the *sepia octopus;* and in front of them in the *calmar;* but in the common cuttle-fish, (*sepia officinalis*) it is at a considerable distance from this organ.

The real bile is poured, as usual, into the alimentary canal.

In the *gasteropodous mollusca*, as the *snail*, the liver is very large, and consists of several lobes, having each an excretory duct. They surround the stomach and intestine, and open by several mouths into its cavity. The *aplysia, onchidium, doris*, &c. have a similar structure.

In the acephalous division of this class, it surrounds the stomach, and pours its secreted liquor into that cavity by many openings; the *oyster* and *muscle* exemplify this.

The proper worms, (*vermes* of Cuvier) the *echinodermata* and *zoophytes* have nothing analogous to this gland.

The author has entirely omitted speaking of the pancreas in this part of his work; probably because there are no remarks of much importance or interest to be made on the subject. The structure of this gland in the mammalia, in birds, and in reptiles, is the same, on the whole, as in the human subject: its form and size, its colour and consistence, and its division into lobules, exhibit some slight and unimportant variations.

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* Lyonet, *Anatomie de la Chenille*, &c. tab. 5 and 12; and Treviranus, *über den innern Bau der Arachniden*, tab. 1, fig. 8.

† Compare the representations which have been given by Swammerdam, Turberville, Needham, and Monro; and Tilesius *De respiratione Sepiæ officinalis*, tab. 1, fig. 1.

‡ See Poli, vol. i. where he represents this fact in several of the *testacea*.

§ Swammerdam, tab. 5 of the *helix pomatia;* and Sal. Stiebel, *Limnei amnalis stagnalis Anatome*. Gotting. 1815.

The termination of its duct or ducts is distinct in birds from that of the *ductus choledochus*. In the mammalia they generally open together, or there is a branch terminating in the *ductus choledochus*, and another opening into the intestine, as in the *dog* and *elephant*, or they may be quite distinct, as in the *hare, porcupine*, and *marmot.* They may be separate or distinct in different individuals of the same species, as in the *monkeys*.

The *skate* and *shark* have a pancreas similar to that of the three first classes of red-blooded animals. In other fishes the situation of this organ is occupied by the *cæcal appendices* or *pyloric cæca;* which afford a copious secretion, analogous, no doubt, to the pancreatic liquor. (These are mentioned in § 119.) The internal surface of these tubes becomes very red on injection, and possesses a glandular and secreting appearance.

The appendices, which form separate tubes in most fishes, are collected in the *sturgeon* into one mass, which is surrounded by muscular fibres. In this body, which has a very manifest glandular structure, the tubes join together, and open into the intestines by three large orifices.

CHAPTER IX.

ON THE URINARY ORGANS.

§ 129. These emunctory organs do not exist in several animals which have a biliary apparatus. They are confined to the red-blooded classes; all of which have kidneys, while some orders and genera have not an urinary bladder.

MAMMALIA.

§ 130. In some animals of this class, as the *bears*,* the kidney resembles a bunch of grapes, being composed of several † small and distinct portions, which are connected by means of their blood-vessels and ureters with the common trunks of those vessels. In many of the *palmata*, as the *seal* and the *otter*, the renal veins form a kind of network, the reticulations of which intersect the furrows between the mammary processes on the outer surface of the kidneys. The suprarenal glands, (*glandulæ suprarenales*) as their name implies, are intimately connected with the kidneys; but their functions, as well as those of the thyroid and thoracic glands, still remain unknown. They appear, from the latest anatomical researches, to have a great sympathy with the sexual organs.‡ The urinary bladder is more loose § in the abdomen of most quadrupeds than in the human subject. It is comparatively much smaller in carnivorous than in herbivorous animals; and is particularly large in the ruminating *bisulca* and the *hare*.

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* Eustachii *Tab. Anat.* tab. 4.

† In the *bear* there are fifty or more, see H. F. Fleming, *Deutscher Jäger.* Leipzig, 1719, p. 126.

‡ See J. F. Meckel's *Abdandlungen aus der menschlichen und vergleichenden Anatomie.* Halle, 1806.

§ Vesalii *Anatomicarum Fallopii Observationum Examen*, p. 126. Riolani *Anthropographia*, p. 241.

Urinary stones, often of very considerable size, are found not unfrequently in horses, whose intestinal concretions have been already noticed. Their composition differs considerably, according to the investigations of Fourcroy and Vauquelin, from the urinary stones of man; since they contain neither phosphoric nor lithic, but carbonic acid.

The structure of the kidney in mammalia displays two very opposite varieties, which may be called the *simple* and the *conglomerate* kidneys. In the former there is a single papilla, which is surrounded by an exterior crust of the cortical substance. This is the case in all the *feræ;* and in some other animals, as many *rodentia.* The other kind of kidney consists of an aggregation of small kidneys, connected by cellular substance. It appears that this form of the gland is found in all those mammalia which either live in, or frequent the water. I have observed it in the *seal* and *porpoise*, where the small kidneys are extremely numerous, and send branches to the ureter without forming a pelvis. Mr. Hunter states that it belongs to all the whales. (*Philos. Trans.* 1807, pt. 2.) The *otter* has the same structure; but its small kidneys are not so numerous as in the animals above-mentioned. (Home, of the *sea-otter*, (*lutra marina*). *Philos. Trans.* 1796, pt. 2.) It is remarkable that the brown bear, (*ursus arctos*) which lives on land, should have this structure as well as the white polar bear, (*ursus maritimus*) which inhabiting the coasts and floating ice of the northern regions, spends much of its time in the water. Mr. Hunter (*loco citato*) concludes, that it is because Nature wishes to preserve an uniformity in the structure of similar animals. But the badger, (*ursus meles*) which is a very similar animal, has the uni-lobular kidney. The number of small kidneys in the bear is 50 or 60; and it appears that each consists of two papillæ. (See the account of the dissection of a bear, by the French Academicians; which is also given in Blasius's Collection. *Anatom. Animal.* tab. 32, fig. 2, 3, 4.)

BIRDS.

§ 131. The kidneys* of this class (with a few exceptions, as the *cormorant*, &c.) form a double row of distinct but connected glandular bodies, placed on both sides of the lumbar vertebræ, in cavities of the ossa innominata; one of the most instructive examples of the remarkable analogy between the structure of the secreting viscera, properly so called, and the conglomerate glands.* The urinary bladder is wanting in the whole class, and the ureters open into the cloaca.†

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* Aloys. Galvani in the *Comment. Instit. Bononiens,* tom. v. p. 9, pl. 508.

AMPHIBIA,

§ 132. Animals of the genus *testudo* and *rana* have an urinary bladder, which is double in many of the frogs, properly so called. The *crocodile,* on the contrary, and several true *lizards* have none. The same remark applies to the serpents, in whom the ureters open into the cloaca.‡

The two large bags, which the author, and also Cuvier (*Leçons d'Anat. comp.* tom. v. p. 237) represent as urinary bladders of the *frog* and *toad,* are stated by Townson to have no connexion with the ureter. Indeed it is very clear that the ureters open at the posterior part of the rectum, while these two receptacles terminate on the front of that intestine. (See his *Tracts and Observations,* p. 66, tab. 3.) He states that the fluid contained in these reservoirs is a pure water. The size of these bags, which exceeds all ordinary proportion to the bulk of the kidney, renders it likewise probable that they are not receptacles of urine. Either of the bags is at least twenty or thirty times as large as the kidney.

FISHES.

§ 133. The glandulæ suprarenales are wanting in this class; and they seem therefore to be confined to such animals as breathe with lungs. Although we cannot perceive of what use an urinary bladder can be to fishes, and animals which live in water, several genera and species have one.

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* See Blumenbach's *Elements of Physiology,* by Dr. Elliotson, § 470 and 471.

† See Fink *De amphibiorum systemate Uropoetico.* Hal. 1817. J. Davy, in the *Phil. Trans.* 1818, pt. 2, p. 303.

‡ See Schreiber in Gilbert's *Annalen,* 1813; and J. Davy, in the *Phil. Trans.* 1821.

CHAPTER X.

ON THE EXTERNAL INTEGUMENTS.

§ 134. Among the various objects and functions of the common integuments, as they are called, one of the most important, and most general, in red-blooded animals, is the office which they perform as emunctory organs. Hence we may introduce here with propriety what we have to say on the subject.

§ 135. The basis of all the other coverings consists in the proper skin, (*cutis vera*) which is common to the four classes of red-blooded animals, and may be regarded as the condensed external surface of the cellular substance, with nerves, blood-vessels, and absorbents interwoven in its texture. This is covered externally by the cuticle, which is very uniform in its structure, at least in such animals as breathe by means of lungs. The rete mucosum lies between these; but it can only be shewn, as a distinct layer of the skin, in warm blooded animals. Lastly, the cuticle is furnished in the different classes with peculiar organs for the formation and excretion of particular matters, viz. *hairs* in mammalia, *feathers* in birds.*

The epidermis of the *cetacea* is quite smooth; and marked with none of those lines which are so often seen in the other mammalia.

It is detached from the surface, in the form of small scales, in all the mammalia, except the *whales;* and in some this happens chiefly at the season when their hair is shed. It gives the skin a branny appearance.

It is in the rete mucosum that the colour of the skin resides; but this part possesses, in very few instances, any brilliancy of colour in the mammalia. It is of a beautiful red and violet on the nose and buttocks of some *baboons;* and silvery white on the abdomen of the *cetacea.* It is remarkably thick on these animals; being about the sixteenth of an inch on the back, and such parts as are of a black colour.

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* See De Blainville *De l'Organisation des Animaux, ou Principes d'Anatomie comparée,* tom. i. Paris, 1822.

The vascular net-work, says De Blainville, in the work referred to by Blumenbach, which is situated immediately over the cutis, occupying its whole surface, is in general of an exceedingly thin texture; it is formed entirely of arterial, venous, and lymphatic vessels, which undergo many complex ramifications and anastomoses; this net-work is spread over the projections situated on the surface of the cutis. The *pigmentum* does not perhaps exist in all animals; it forms at the surface of the vascular net-work a layer more or less defined, of slight consistence, semi-fluid, and in effect composed entirely of very minute grains, agglutinated to each other, without any organic continuity between their own particles or with the other portions of the skin; it is a sort of artificial membrane or depository, which is variously coloured, and which seems to be exhaled by the parietes of the veins. This *pigmentum* and the vascular net-work are both crossed by the nervous extremities which meet at the surface of the skin, sometimes under the form of papillæ. These two parts of the skin are those, which, since the time of Malpighi, have been known by the name of Malpighi's net-work, *corpus reticulare, reticulum mucosum,* on account of the sort of net-work which they form for the passage, not only of the nervous papillæ, but also of the accessory parts. They are both in my opinion, says De Blainville, the source of the colouring matter, and the *pigmentum* is the depository of that matter.

The colour of the skin is different in the inhabitants of different countries; in some it is white, in others brown, yellow, red, and black. This variety depends on something peculiar in the constitution, and in no way on climate; it arises just from the same cause as the difference in the colour of plants and animals. This is proved by the fact of the Negro and American children being born with the colour peculiar to the respective races, as well as by the peculiar organization of the skin. Humboldt says, that the children in Peru, Quito, on the coast of the Caraccas, on the banks of the Orinoco, and in Mexico, are never white at the time of birth; and the Indian caciques, who are well provided for, and live in houses, are of a reddish brown, or copper colour, all over the body, with the exception of the palm of the hand and sole of the foot. Vid. Rudolphi's *Physiology,* by Dunbar Howe, § 43.

MAMMALIA.

§ 136. The cutis of this class varies infinitely in thickness. It is extremely thin and delicate in the wing of the *bat,* and on the contrary exceedingly thick in the *rhinoceros, elephant,* &c.

also in the web-footed animals, particularly the *walrus*.* The form of the papillæ on its external surface is very various in the different animals of this class, as, indeed, in different parts of the same animal. They are sometimes threadlike, as on the paws of the *bear*, and are very elegant on the teats of the true whale (*balæna mysticetus*). I have also observed this in several macacos (*simia cynomolgus*) and mandrils (*papio maimon*).

The colour of the rete mucosum varies, even in individuals of the same species, as in the different races of mankind. It is thickest in some *cetacea*.

I have had an opportunity of examining the skin of the cetacea in a *balæna boops*, and in a dolphin (*delphinus delphis*). In both the rete mucosum was very thick; but by no means equal to the breadth of a finger, as is represented in a whale of uncertain species in the Museum Gaubianum.†

In some spotted domestic animals, particularly the *sheep*, *rabbit*, and *dog*, there is a remarkable connexion between the colour of the palate, and even sometimes of the iris, and that of the skin; for spots of similar descriptions are found in both parts.‡

The cuticle is often of very unequal thickness in particular parts, from the different purposes to which it is destined. Thus it is very thin on the points of the fingers in *apes* and *baboons*, when compared with its great thickness where it covers the callosities on which they sit. In various *multungula*, particularly the elephant, it forms a kind of horny processes,§ lying close together in several parts of the body. But differences of this kind are too numerous to admit of their being all noticed in this work.

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* Hence, the old Normans used to make their almost imperishable cables from the skin of this animal. See J. Spelman, *Vita Ælfridi magni Anglorum Regis*, p. 205. Oxon.

† See *Mus. Gaubian.* 1783, p. 14.

‡ See among other works, Schneider's additions to his German translation of Monro's *Physiology of Fishes*.

§ These processes, as I observed them on the proboscis of the elephant, appeared very similar to the warty cuticle of the two English *porcupine-men*, whom I saw several years ago, and which has been well described by W. G. Tilesius, in his *Monograph über die beiden sogenanten Stachelschweinmenschen aus der Familie Lambert*. Altenb. 1802.

Villi, or papillæ of the skin are found on those parts which correspond to the toes and fingers of man. They exist also on the trunk of the elephant, and on the snout of the mole and pig.

The cutis of mammalia is much thicker on the back than on the belly.

§ 137. Hairs, at least single ones, are found in all adult mammalia, even without excepting the *cetacea*. In various states of thickness and strength they constitute every intermediate substance, from the finest wool to the strongest quills of the porcupine. Thick bristles, and hairs, as they are found for instance in the tail of the *elephant* and other animals, resemble horn, or fish-bones in texture; while, on the other hand, both these substances may be easily split into a kind of bristles. Hairs are commonly cylindrical; some, however, are broad with two sharp edges; as in the toes of the *ornithorhynchus* and the common *porcupine*. Others, as the whiskers of the *seal*,[*] are also flat, but have rounded and denticulated margins, so that they have a kind of knotty, or jointed appearance. Something similar may be observed in the hair of some cloven-hoofed[†] animals, and most remarkably in that which covers the scent-bag of the musk (*moschus moschiferus*). These are at the same time filled with a very loose medullary texture, and consequently very brittle. Some are thick and firm, but perforated by a narrow tube, which runs through their axis, as the long stiff whiskers of the *phoca ursina*. The hairs on the tail of some species of *porcupine* are entirely hollow, like the quill of a feather.

The hair is the most incorruptible part of the body, and possesses in great perfection both kinds of reproductive power; viz. the *natural*, which takes place in a healthy state, and the *extraordinary*, which is exerted after an accidental loss.[*] It is electrical in some species, and serves in those animals which possess much of it, as a mode of excreting superfluous phosphoric acid.[†]

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[*] Albini *Annotat. Academ.* lib. 3, p. 66.

[†] In consequence of a degeneration of the formative impulse, which seems to reside chiefly in an unnatural formation of the skin, the hair of the human subject may assume an unusual appearance, similar to that of some quadrupeds, particularly of the *goat* and *deer* kind. This was the case with a woman from Triers, who was shewn here, as well as in many parts of Europe, in her seventeenth year. See Lavater's *Physiognom. Fragmente*, part 4, p. 68. And the supplement to Buffon, vol. iv. p. 571.

There are secretions from the integuments in some species of mammalia, manifesting themselves by peculiar smells, which constitute specific characters in some of the horse and dog-kind, as completely as the national smell of certain varieties of the human race.[‡]

The skin secretes a matter of peculiar odour in some races. "The Peruvian Indians," says Humboldt, (*Political Essay*, i. 245) "who in the middle of the night distinguish the different races by their quick sense of smell, have found three words to express the odour of the European, the Indian American, and the Negro; they call the first pezuna, the second posco, and the third graco." He adds, "that the casts of Indian or African blood preserve the odour peculiar to the cutaneous transpiration of these primitive races."

The following quotation from the 2d chapter of the author's *Manual of Natural History* (*Handbuch der Naturgeschichte*) explains the terms made use of in the foregoing paragraph, represents the subject in an interesting point of view, and contains the result of some curious experiments.

In speaking of the growth of organized bodies, we must notice their power of reproduction—that wonderful property of restoring or renewing parts that have been mutilated or entirely lost. This is one of the wisest provisions of nature for guarding animals and plants against the numerous dangers by which they are surrounded. Hence, when viewed in connexion with the system of growth altogether, it constitutes one of those grand characters which distinguish the machines that proceed from the hand of the Creator, from all the productions of human skill. The springs and wheels of mechanical instruments have no power of repairing themselves when injured or worn; but such a power, in different degrees, is imparted to every animal and plant.

At different periods of the year several organized beings lose by a spontaneous and natural process certain parts of their body, which are subsequently renewed. Examples of this occur in the fall of the stag's horns; in the moulting of birds; in the renewal of the cuticle of serpents, and of the larvæ of insects, and that of the shell of the crustacea; the fall of the leaves of trees, &c. This may be called *ordinary* or *natural* reproduction.

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[*] Blumenbach's *Manual of Natural History*, by Gore, p. 27.

[†] Fourcroy, *Systeme des Connoissances Chirurgiques*, vol. ix. p. 270.

[‡] I have said more on this subject in the third edition of my work *De Generis Humani Varietate Nativa*, p. 163.

The second, or *extraordinary* kind of reproductive power is that by which wounds, fractures, or any accidental mutilation or loss of parts of an organized body are remedied or restored. Man indeed, and such animals as are nearly allied to him, possess this property in a very limited degree, while its strength and perfection are truly astonishing in several cold-blooded animals, as the water-newt, the crab and lobster, snails, earth-worms, (*lumbricus terrestris*) sea-anemones, (*actinia*) the starfish, (*asterias*) fresh-water polypes, (*hydra*) &c.

Some experiments on this reproductive power require a hand exercised in such employments, together with various precautions, and a favourable combination of circumstances, for their success. Hence persons must be cautious in concluding against the truth of any statement, because their own experiments do not succeed. After several fruitless attempts on this subject, I have lately succeeded in observing the reproduction of the whole head of the snail, (*helix pomatia*) with its four horns; which occupied about six months.

I preserve in spirits a large water-newt, (*lacerta palustris*) from which I extirpated nearly the whole eye several years ago. All the humours were discharged, and then four-fifths of the emptied coats were cut away. In the course of ten months an entirely new eye-ball was formed; with cornea, iris, crystalline lens, &c.; and this is only distinguished from the same organ on the opposite side by being smaller. See the *Gottingen Literary Notices* for 1787, pp. 28, 30.

BIRDS.

§ 138. The integuments of birds have the same three parts with those of mammalia. Some are furnished with hair in particular situations; as the *vultur barbatus*, the *raven*, and the *turkey*. Others, as the *cassowary*, have long spines like fish-bones in their wings, which approach in the tubular structure of their roots, to the formation of feathers; the universal and peculiar covering of this class of animals. The particular differences in the formation of the feathers are innumerable.* Among the most remarkable are the small scale-like feathers (*squamulæ ciliatæ*) of the *penguin*'s wing; and the horny, flat, and pointed processes on the tip of the neck, and wing-feathers of the *common fowl* in its wild state; and on those of the *Bo-*

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* See Nitzsch's *Pterographische Fragmente*, in Voigt's *Neu. Magazin*, ii. p. 393.

hemian chatterer (*ampelis garrulus*). Several birds in different orders have two or more feathers arising from a common quill.

In a young *ostrich*, which had just quitted the egg, and which now lies before me, there are as many as twenty feathers on the back, proceeding from a single barrel.

In the encysted tumours of the ovaries, large collections of hair are not unfrequently found, and in the thoracic and abdominal viscera of tame geese and ducks preternatural formations of feathers, covered over with a kind of fat, are also met with.*

The periodical renewing of the feathery covering, at what is called the moulting season, takes place in a short space of time, and comes therefore more under our observation than the change of the hair in mammalia. This process has afforded a very interesting physiological remark, which has been often made in several species of those birds in which the male and female have different plumage; viz. that as the latter ceases in her old age to lay eggs, she obtains the male plumage.

Lastly, the integuments of birds serve the office of emunctory organs, which is proved even by the process of moulting, as well as by the separation of peculiar matters from the skin. Thus the cockatoo, (*psittacus cristatus*) as well as some other species of *psittaci*, and several birds of different orders, have a large quantity of white mealy dust discharged from their skin; particularly at the pairing time.

AMPHIBIA.

§ 139. The very various integuments which are found in the different orders and genera of this class, consisting of shields, rings, scales, or simple skin, are covered externally with cuticle, which is frequently separated in many of these animals, as in the *snake*, forming what is called snakes-shirt (*lebèris, senecta*) and *water-newt.*

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* Similar cases are mentioned in Harrow's *Seltenheiten*, b. i. s. 255. Penada *Osservaz. e memorie Anatom.* Pad. 1800; and Otto *Seltenen Beobachtungen zur Anatomie.* Bresl. 1816.

The process of separation is repeated every week for some time in the latter animal, particularly in spring and autumn. Some, which have small fine scales, as the *chameleon,* or a simple skin, as some *frogs*, change their colour occasionally, either from difference in the light or warmth, or from the effect of their passions.

The skin of the frog and toad does not adhere to the subjacent parts, as in other animals, but is attached to them only at a few points, and is unconnected elsewhere ; so that it may be compared to a bag containing the animal.

The reflection of coloured objects on the glittering scales of the *chameleon*, probably gave origin to the fable that its colour is regulated by that of the bodies near which it is placed.

FISHES.

§ 140. All fishes, without exception, are covered with scales, which are bare in those which inhabit the open sea, but on the contrary are covered with a mucous membrane in those which live on coasts, or in fresh water. It is remarkable that the colour of the skin in some fishes, as for instance, the *mullet*, (*mullus barbatus*) depends on that of the liver.* The scales are not changed like hair and feathers, but are perennial; and are said to receive yearly an additional layer to their laminated texture, from the number of which the age of the animal may consequently be determined.

The lower orders possess in general an epidermis. In the *testacea* it usually covers the surface of the shell, and obscures the brilliancy of that part until it is removed. It may be seen by plunging a snail-shell into boiling water. It is very thick and villous in some species, as in the *arca pilosa.*

Crustacea have it; also insects, both in their perfect and larva states. It is shed in the latter several times before the change to the state of chrysalis ; seven times in most of the *butterflies* and *bombyces.*

It is very distinct in the vermes, as in the common *earthworm* and *leech*, which often shed it. In the *sipunculus saccatus* it is loose and not adherent to the surface.

Hairs are formed in small bulbous bodies implanted in the true skin, and grow from their base.

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* Santorini *Obs. Anatom.* Venet. 1724, vol. iv. p. 4.

If one of the large hairs, which grow on particular parts of some animals be examined with glasses, its surface appears grooved, as if it were composed of several filaments; and one or two canals are discovered in the substance of the hair, containing a kind of fluid, which has been called the medulla.

In the *hedgehog*, *porcupine*, &c. these filaments are covered with a layer of horny substance; and the cavity is filled with a white spongy matter.

The colour of the hair is influenced in great measure by that of the rete mucosum, and this circumstance is particularly observable in the human subject. Its texture is much modified by climate and mode of life. The *dog* in Siberia, and the *sheep* in Iceland, are covered with a kind of long and stiff hairs, while the same animals, in very hot countries, as in Guinea, lose this covering altogether. A species of *goat* furnishes the long and silky hair which is manufactured into the valuable shawls of Cashmere. The *cat*, *rabbit*, and *goat*, are covered with a very long and peculiar kind of hair in Angora, a small district of Asia Minor, and the superior qualities of the Spanish wool are well known.

This seems to be the proper place for considering, in a cursory manner, the other insensible parts, which are found on the surface of the body.

The *horns* of the mammalia are generally formed on processes of the frontal bone, which they cover in the manner of a sheath, as a glove does the finger. They consist of a solid, insensible, and elastic substance, which in many cases has a fibrous appearance, as if it were composed of an aggregation of hairs. This structure is most particularly remarkable in the rhinoceros, where the horn is solid, and situated over the nasal bone. The fibres analogous to hairs are very distinct, and are observable at the base of the horn, detached from its substance in the form of bristles. The mass of the horn is entirely pervaded by innumerable pores.

In those animals which have a long process within the horn, the os frontis begins to form a tubercle, about the seventh month of conception. This being gradually elongated, elevates the integuments, which become callous, and harden as the horn is lengthened. Between the bone and the latter part a soft vascular substance is interposed, from which the horn is produced by means of successive additions to its base and internal surface.

The *nails* and *claws* of animals are formed just like horns, they cover a process of the last phalanx, which is analogous to the frontal process of the horn, and grow from the root or base, to which the integuments are attached, while they wear away at the loose edge.

The *hoof* of the *horse*, *ass*, &c. is a horny covering of the last phalanx; similar, in its structure and formation, to the parts just mentioned, but including the whole of the bone. Its internal surface, in the horse, is formed into a vast number of thin plates, which are placed alternately with corresponding laminæ of the vascular substance, and constitute a most close connexion between the two parts.

This union is so firm, that, when the inferior portion of the hoof has been removed, a horse may be trotted roughly without the foot being separated from the upper part of the hoof.

The body of a bird which has just quitted the egg is covered with hair instead of feathers. Fasciculi of hairs are produced from one common bulb, which is the rudiment of the future feather. In a few days a black cylinder appears, which opens at its extremity, and gives passage to the feather. The opposite end receives those blood-vessels, which supply the vascular substance in the barrel of the feather; when the stalk of the feather has received its complete growth this vascular body is dried up, and presents the well-known appearance in the barrel of quills.

The parts which have just been described, as well as the epidermis, and the scales, or rather hard coverings of reptiles and fishes, possess neither vessels nor nerves; and therefore the whole superficies of an animal's body is really insensible, and constitutes a dead medium, through which impressions are conveyed to the subjacent living parts.

CHAPTER XI.

ON SEVERAL PECULIAR SECRETIONS.

§ 141. It is necessary that we should take notice of some organs destined for the secretion of peculiar fluids, the use of which is not hitherto sufficiently determined. These occur in particular classes, or in certain genera and species of animals, and may be most conveniently considered here, at the end of that division which treats of the natural functions.*

MAMMALIA.

§ 142. Besides the well-known salivary glands, there is another, which has been described by Nuck in the orbit, particularly of the *dog*, and some other predacious animals, which has an excretory duct opening near the last tooth of the upper jaw.† Professor Jacobson‡ has described a remarkable secreting gland, which is situated in man and in many other mammalia, and probably in all birds, on the external side of the nostrils, the excretory duct of which opens at the anterior extremity of the lower concha. He names this organ after its illustrious discoverer, *la glande nasale de Stenonis.*§

§ 143. Both sexes of both species of the *elephant,* viz. the *African* and *Indian,* have a considerable gland‖ at the temple, between the eye and meatus auditorius, secreting in the rutting season a brownish juice, which is discharged through an opening in the skin.¶

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* See Tiedemann, in Meckel's *Archives,* vol. ii. p. 112.

† Nuck, *Sialographia,* tab. 3 and 6.

‡ *Bulletin des Sciences de la Société philomatique,* for April, 1813.

§ Stenonis *Observat. Anatomie,* 1662, vol. xii. p. 105. *Analyse des travaux de la Société Veterinaire de Copenhague,* 2 Report, 1815, 4; and Nitzsch, in Meckel's *Archives,* vol. vi. p. 234-269.

‖ See the *Histoire des Animaux* of the Parisian academicians, part 3, p. 138; and Camper's plates on the anatomy of the elephant, tab. 10, 11.

¶ This circumstance has been remarked of old, and has been noticed in the

As far as regards the structure of the organ, this secretion resembles most that of the gland placed at the back of the Mexican musk-hog, or pecari (*sus tajaçu*).

This remarkable gland is found on the back of the animal, over the sacrum. It is of a considerable size, (between two and three inches long, and above an inch broad) and is composed of several lobules, whose ducts join into one canal, which penetrates the skin. It furnishes a secretion of a very pleasant musk-like odour, from which Tyson denominated the animal *aper moschiferus*. The opening of this part on the back has been described by many authors as the navel. (Bartholin. *Cent.* 2, *Hist. Med.* 96.)

Tyson in the *Philos. Trans.* No. 153, or in his *works*, London, 4to. 1751, with a good delineation of the gland.

§ 144. Several ruminating *bisulca*, and the *hare*, have on the outer side of the upper jaw, near the ossa nasi, *sebaceous sinuses*, which have received that name from the adipose and viscous substance which is separated there in great abundance in some animals, and which is well known in the *stag*, where it is supposed to be of a lacrymal nature.*

§ 145. In most of the *ruminating animals*, and in the *hare*, there are cavities in the groins, near the genitals, called by Pallas *antra inguinalia*, and containing a strong-scented sebaceous substance secreted from glands which lie under the integuments.†

§ 146. Some other mammalia have pouches on the abdomen, covered internally with a fine hair, and containing fatty secretions of peculiar odours. Of this kind are the bags near the anus of the *badger*,‡ and that which contains the teats of the female marsupial animals.§

Indian Mythology. See Wilford, in the *Asiatic Researches*, vol. iii. p. 443; it is noticed also in Strabo. Compare Beaulieu, *Voyage aux Indes Orientales*, p. 105, (in the collection of Thevenot the elder, vol. ii.). J. W. Heydt's *Ostind. Schauplatz*; and particularly A. W. Schlegel's *Indische Bibliothek*. p. 165.

* Vide Ph. Seifert *Spicilegia Adenologica*. Berol. 1823, 4, p. 13, tab. 2.

Y. Y. Wepfer, in E. N. C. Dec. 11, a. b. Obs. 118.

Chabert and Heron, in the *Journal de l'Agriculture*, &c. May, 1778, p. 87.

† Wepfer in the same collection, *Dec. I. A.* 3, *Obs.* 167.

‡ J. Gottl. Walter, in the *Mémoires de l'Ac. des Sc. de Berlin*, 1792.

§ The yellow matter contained in this pouch was compared by Tyson with that which is secreted in the axilla of the human subject. *Phil. Trans.* vol. xx. p. 120.

§ 147. There are also, in the *badger* and the *opossum*, as well as in several other carnivorous animals, (both among the *digitata* and *palmata*,) peculiar glands and bags at the end of the rectum, secreting a yellow substance of a strong and disagreeable smell in its recent state, and which frequently gives to their excrement a kind of musk-like odour.*

These anal bags are of a spherical form, and have a small round opening just at the margin of the anus. They seem to belong particularly to the carnivorous animals. They may be seen very well in the cat. Their secretion possesses that strong disagreeable odour which characterizes so remarkably many animals of this order, as the fox and all the weasel tribe, and which has even made the polecat proverbial in common language, and has bestowed on it its scientific name, *mustela putorius*. Some American species exceed the fetor even of the polecat. This is the case with the *viverra mephitica* and *coasse* (the skunk and squash). They pour out the fetid matter when pursued; and are thereby effectually defended, as neither man nor animal can approach them.

These parts are not, however, confined to the *carnivora*, as several *rodentia* possess them.

§ 148. These anal glands must be distinguished from another kind of similar glands and bags, which also secrete strong-scented matters, but seem to be rather connected with the genitals.† These are found in some of the same carnivorous animals which possess the anal glands, as the *lion*, the *civette*, &c.; also in many *herbivora*, which want the latter organs; in some of whom they exist in both sexes, as in the *beaver*,‡ the *ondatra*,§ (*mus zibethicus*) &c.; in others they are peculiar to the male, as in the musk animal,‖ whose pouch is found in the prepuce near the navel.

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* See Grew, *Museum Regalis Societ.* tab. 23, where he represents these bags in the *polecat, weasel, fox,* and *cat.* Daubenton, tom. ix. tab. 4, in the *lion,* tab. 16, in the *panther,* tab. 33, in the *civette,* tom. vii. tab. 13, in the *otter.* Mitchell, in the *American Museum,* vol. v. p. 487.

† Tyson, who first carefully examined the different kinds of what he calls *scent bags,* has not distinguished them from each other. See Plot's *Natural History of Oxfordshire,* p. 305; and the *Phil. Trans.* vol. xiii. and xx.; also Haller, *Elem. Physiol.* tom. vii. p. 147, &c.

‡ Daubenton, tom. viii. tab. 41, 42.

§ Sarrazin, in the *Mém. de l'Acad. des Sci.* 1725, tab. 12, 13.

‖ Pallas, *Spicileg. Zoolog.* 13, tab. 6.

It is from these glands, and not from the testicles, as naturalists have absurdly supposed, that the substance called *castoreum* is produced. A delineation of the parts, from the dissection of the Parisian academicians, may be seen in the collection of Blasius. *Anatom. Animalium.* tab. 13.

That valuable article of the materia medica, *musk*, is produced from similar glands in the *moschus moschifer*, (the musk) an animal found in the mountains of Thibet, and the southern parts of Siberia.

§ 149. We must also mention here the glandular cavities, covered internally with hair, which are found in the feet of several ruminating *bisulca*, and particularly in the *sheep*. They have an excretory duct opening at the junction of the toes;* and the obstruction of this, particularly from a long continuation of wet weather, occasions troublesome symptoms.

BIRDS.

§ 150. Although birds do not masticate their food, several of them, particularly among the *pici*, have considerable *salivary glands*† at the sides of the lower mandible. The secretion of these glands serves to facilitate the numerous and strong motions performed by the tongue in deglutition.

The *pancreas* is of considerable size, particularly in those birds of prey which do not drink; its form and structure vary considerably.

It has been already stated that salivary glands, in the proper sense of the term, do not exist in birds, and that the parts which the author mentions here must be regarded in a different point of view.

§ 151. The glands which secrete the oil, on the upper part of the tail, are largest in aquatic birds; in some of which, as the *anas moschata*, the secreted substance has a musk-like odour. In that race of the common-fowl, which has no tail, (the *gallus ecaudatus*) this organ no longer exists.‡

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* R. Livingstone, in the 2d vol. of the *Society of New York*, p. 140. J. F. Neimann, in his *Taschenbuch für Hausthierärzte*, vol. ii. s. 87.

† V. A. Huber *De Lingua Pici viridis*.

‡ Reaumur, *Art de faire éclorre les Oiseaux Domestiques*, tom. ii. p. 332.

AMPHIBIA.

§ 152. I do not think it probable that the part which has often been considered as a *pancreas* in this and the following classes of animals, really deserves that name. Zootomists have not been able to agree on this point; Charas took that to be the pancras of serpents, which Tyson with the ancients called the spleen.

Anal glands, which disseminate a strong specific odour at certain times are found in some animals of this class; for instance in the cayman, (*lacerta alligator*) and the rattlesnake.*

§ 153. An acrid fluid exudes through numerous pores of the skin in some reptiles, when they are irritated; as in the *salamander* and in *toads*. It is said that the *gecko* secretes a really venomous fluid between its toes. But there is a much more dangerous kind of poison formed in some serpents, which are distinguished from the innocent ones by the organs pointed out in a former part of this work.†

There is found in the crocodile, on each side of the lower jaw, and just under the skin, a gland, whose duct opens externally. It secretes a substance smelling like musk.

There are situated on the heads of most serpents five pairs of glands; the first is a small, long, round, and very hard gland, situated at a very little distance from the skin, close behind the anterior extremity of the lower surface of the mouth. These may undoubtedly be compared to the sub-lingual glands of other animals. Cuvier has found them in the *amphisbænæ*, where they are in proportion the largest; but neither he nor any other author mentions their existence in the other species, although with the exception of the *typhlops*, I found them in all the species which I examined.

The second is situated more behind, and to the inner side of the eye: in general it is of a considerable size, and of a white soft colour. Meckel found them in the *amphisbæna alba* and *fuliginosa*; also in the *eryxjaculus*, *tortrix ocytale*, *elaps*, they are very considerable. They are generally situated without and behind the orbit, particularly in the *coluber*, *tortrix*, and *eryx*, but in the *boa*, *python*, and poisonous serpents, part of the gland lies within the orbit.

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* Tyson, in the *Philos. Trans.* vol. xiii. p. 38.

† On the peculiar poison-glands in the *coluber* (*trigonocephalus*) mutus and berus, see Seifert, p. 3, tab. 1, fig. 1, 4; on the salivary glands of serpents, see Tiedemann, in the *Denkschriften der Akad. der W. zu München für*, 1813; and on some other secreting organ in the orbitar region of many poisonous serpents, see P. Russel and Home in the *Phil. Trans.* for 1804.

The third, which is not so common as the two preceding, is a gland of some length, and situated close to the rami of the lower jaw; there are numerous excretory ducts, which open externally through the teeth of the lower jaw, in a simple longitudinal row. Cuvier has described them in the *coluber* and *boa;* afterwards Tiedemann and Cloquet gave delineations of them as they are found in the *coluber natrix*, and Rudolphi as they are found in the *vipera vera;* they have since been found in several other species of serpents. They correspond in their form, structure, and situation, to the buccal and labial glands of mammalia.

The fourth is situated externally, close to each side of the upper jaw. In the *vipera dubia* Meckel found a small gland at the corner of the mouth; Tiedemann found them in the *anguis*, although Meckel who examined three fine specimens was not able to detect them. In the *coluber*, *amphisbæna*, *tortrix*, and *eryx*, this gland is very considerable; in the *python, crotalus, vipera vera*, they are of moderate size; in the *elaps* they are extraordinarily small, and intimately connected with the excretory ducts of the poisonous glands situated beneath them.

The fifth are the *poison-glands:* these are the most remarkable, and it is difficult to conceive how they could have been overlooked by the earlier anatomists. They are situated above the upper jaw, behind and below the eyes; they are surrounded by a very strong muscle, and in fact embedded in it, so that they cannot be seen until the muscle has been divided. They are of some length, and have a laminated texture; internally they have a considerable cavity, and are distinguished from all the other glands by a very long excretory duct which takes its course along the outer surface of the upper jaw, and opens above and before the poison teeth in such a manner into the sheath, that the poison flows into the upper opening of the tooth.

Meckel has come to the following conclusions on the number and proportional size of the glands of serpents.

1. Several poisonous serpents, viz. the *crotalus, naja, vipera vera, elaps lemniscatus*, possess the greatest number of glands; for, in addition to the poison and salivary ones, they also have five pairs.

2. Four pairs only exist: 1, in the *vipera dubia*, for besides the poison glands, they have merely the lachrymal and lingual, and a slight rudiment of the labial at the angle of the mouth; and 2, in the *coluber python, amphisbæna*, there are also only four pairs.

3. The *anguis fragilis* has four pairs, the upper labial glands only being wanting; but in the *trigonocephalus* both pairs of the labial glands are wanting.

4. Lastly, in the *typhlops crocotalus*, all or nearly all are wanting.

5. Those serpents which have no poison glands possess all the others in a greater state of development. Both the poison and other glands have excretory ducts. Vid. Meckel's *Archiv. fur Physiologie*, Lip. 1826.

FISHES.

§ 154. The most universal secretion in this class, which comes under the present chapter, is that of the mucus, which besmears their skin and scales, and which is formed in canals* lying near the *lateral lines,* and in the same direction with them; one or more of these canals running on each side from the head to the tail-fin. In some fishes the mucus is poured out in the intervals of the scales; but in others those parts are perforated by regular openings for its discharge.†

Cuvier represents the tubes which open in the course of the *linea lateralis* of fishes, as the excretory ducts of two glands placed above the orbits. (*Leçons d'Anat. comparée,* tom. v. p. 260.)

In the *skate* the openings are not confined to any particular part, but are scattered over the surface. The tubes radiate from one point, just above the angle of the jaw; and the third branch of the fifth pair of nerves is distributed at that part; its filaments accompanying the tubes.

For an account of the electrical organs of fishes, which must be considered as parts secreting the electrical matter, see § 218; and for their swimming bladder, in which a secretion of air is effected, § 187.

INSECTS.

§ 155. There are no true conglomerate glands, nor analogous parts in insects; but their different secretions are performed by loose vessels.‡ Besides the different secretions of peculiar matters, which belong exclusively to single species, as the vapour, which some carabi (*carabus crepitans, marginatus,* &c.) discharge, and the strong odours with which several of the bug-kind defend themselves in case of necessity, two kinds of secreted fluid deserve to be particularly remarked in this class: the silk which is formed by the larvæ of phalenæ* (moths) and by spiders;† and the *poison* with which several hymenopterous ‡ and apterous § insects are armed.

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* Professor Jacobson, after a careful examination, is of opinion, that these ducts in the *cartilaginous fishes* may be regarded as organs of a peculiar sense, *Nouveau Bulletin des Sciences pour la Soc. Philomatique,* 1813.

On the curious structure of the numerous canals on the head of several species of the *ray* and *shark,* see Stenon, who has the merit of having discovered them, in his classical work, *De Musculis et Glandulis,* p. 42; and *Elementor. Myolog. Specimen,* p. 72; also the recent work of Lorenzini, *sulle Torpedini,* pp. 7 and 21.

† A. Q. Rivinus, in the Leipsic *Acta Eruditorum,* 1687, p. 161; and Perrault *Essais de Physique,* tom. iii. tab. 20.

‡ Cuvier, in the *Mémoires de la Société d'Hist. Nat. de Paris,* an 7, p. 40.

The wax, which is prepared by the honey-bees, and by the Indian *coccus mellificus,* deserves to be enumerated among the secretions which are peculiar to animals of this class.

Almost all the larvæ or caterpillars spin for themselves some kind of covering before their metamorphosis; but it is the silkworm only (*bombyx mori*) that furnishes the materials of our various silk manufactures, as the thread which it forms is very pliant and abundant, and can be easily unrolled.

The secretory organs, which furnish this matter of silk, are the same in all larvæ. They consist of two long tubes, at first small and tortuous, but growing gradually larger to form a kind of reservoir, and terminating in a single very small tube, which opens under the lower lip. It is by moving its head from side to side that the animal draws out the silk.

In those insects which possess stings, the irritating or poisonous fluid is formed in a peculiar bag, which sends a duct to the sting. The latter part is hollow, and its tube opens externally. It is contained in a sheath, and barbed at the sides of its point, so that it usually remains in the wound which it inflicts. A delineation of these parts in a magnified view may be seen in Swammerdam, tab. 27 of the English translation.

VERMES.

§ 156. The most remarkable secretions in this class take place in the *testacea.* There is one of these common to the whole class; viz. the formation of the calcareous matter of their shells,‖ which takes place in a peculiar viscus lying near the heart (*sacculus calcarius,* Swammerd. *glandula testacea,* Poli). The celebrated purple¶ colour is formed in some marine genera; as the *buccinum lapillus* and *echinophorum, murex brandaris* and *trunculus, helix ianthina, arca nucleus,* &c. Lastly, some bivalves, under extraordinary circumstances, form pearls* on the inner surface of their shell.

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* See Lyonet, tab 5 and 14.

† Rösel, tom. iv. tab. 29.

‡ See Swammerdam's plates of the organ in the bee, tab. 18 and 19.

§ Rich. Mead *Opera Medica,* tom. ii. tab. 3.

‖ Swammerdam, tab. 5, of the *Helix Pomatia.* Poli, tom. ii. tab. 20, of the *Venus Chione;* tab. 26, of the *Arca Pilosa.* Dr. Wohnlich *De Helice Pomatia.* Wirceb. 1813, p. 23; and Prof. Jacobson, in Meckel's *Archives,* vol. vi. s. 370.

¶ See Ström, of the *Buccinum Lapillus,* in the 11th vol. of *Kiöbenh. Selsk. Skrifter,* p. 30,

Several *acephalous mollusca* produce a kind of silk, similar to that of the larvæ of insects. It is sometimes called the *beard;* and is employed by the animal in order to attach itself to rocks, &c. It is formed by a conglomerate gland, placed near the foot, which latter part draws out the silk from the excretory duct, and moulds it in a groove on its surface. The sea muscle, (*mytilus*) the *pinna,* and *perna,* exemplify this structure. The pinna produces it in such quantity, and of such quality, as to admit of its being manufactured into gloves, which is done at Messina and Palermo. (Blumenb. *Handbuch der Naturgeschichte,* ed. 6, p. 438.)

The black inky fluid of the cuttle-fish, which has often been supposed to be the bile, is a very singular secretion, that must be noticed in this place. The bag in which it is contained has a fine callous internal surface, and its excretory duct opens near the anus. The fluid itself is thick, but miscible with water to such a degree, that a very small quantity will colour a vast bulk of water; and the animal employs it in this way to elude the pursuit of its enemies. According to Cuvier, the Indian ink, which comes from China, is made of this fluid. (*Leçons d'Anat. comp.* tom. v. p. 262.)

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* Poli, tom. i. Introduction, p. 19.

THE VITAL FUNCTIONS.

THE VITAL FUNCTIONS.

CHAPTER XII.

ON THE HEART AND BLOOD-VESSELS.

§ 157. A PERFECT circulating system, to which on the one hand fluids are brought by the absorbents, to be converted into blood; and from which, on the other hand, various juices are separated in glands, and viscera of a glandular structure, appears to belong universally and exclusively to red-blooded animals. A pericardium exists in all these animals. Parts of such a system, particularly a heart, and certain vessels connected with it, are found in some genera of the two white-blooded classes. It is surprising that so many good anatomists, among whom are Blasius, Peyer, Harder, and Tozzetti, should have denied the existence of a pericardium in the hedgehog. The membrane is indeed very delicate in this animal, and it requires some care to avoid tearing it in opening the chest.

MAMMALIA.

§ 158. The internal structure of the heart is the same as in man; but its situation in quadrupeds and *cetacea* differs from that which it has in the human subject. It is in the former situated more longitudinally with respect to the body, resting rather on the sternum than on the diaphragm. Hence the pericardium of these animals, with a few exceptions, is not connected with the diaphragm* as in the human subject; the portion of the inferior vena cava within the chest is proportionably longer.

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* See Morgagni, in his *Epist. Anat.* p. 302, edit. 1764.

The heart of the *orang-outang* is placed obliquely, like that of the human subject; but in other *simiæ* the apex only is a little inclined to the left, and just touches the diaphragm.

§ 159. The larger adult *bisulca* and the *pig* have two small flat bones, (which have been called, particularly in the stag, *bones of the heart*) where the aorta arises from the left ventricle. The common notion, that they serve as a support to the valves,* does not much elucidate the subject.

The right auricle receives in the *porcupine* and *elephant* two anterior venæ cavæ; the left of which opens near the communication with the ventricle.

§ 160. It has been supposed that the amphibious animals of this class and the *cetacea* have an open *foramen ovale*, like that of the fœtus, in their septum auricularum. And the necessity of such an opening has been inferred from their way of life; since they often pass a considerable time under water without breathing. This supposition has been fully refuted by the repeated dissection of adult animals of this kind, which has shewn that an exception from the general rule very rarely occurs.

I possess a very singular heart of an adult seal, the *foramen ovale* and *ductus arteriosus* of which are completely open. Both the arterial trunks, and particularly the aorta, form large, and as it were aneurismatic expansions.†

In several genera and species of web-footed mammalia, and *cetacea* (that is, in the *common* and *sea otters*, in the *dolphin*, &c.) particular vessels have been observed to be considerably and constantly enlarged, and tortuous. This structure has been principally remarked in the inferior vena cava; where there can be no doubt that it serves, while the animal is under water, to receive a part of the returning blood, and to retain it until respiration can be again performed, and the lesser* circulation be thereby again put in action.

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* C. I. Keuchen, *De Ossiculis e Cordibus Animalium.* Groning. 1772, 4. Luthii *Observ. Zootomiæ,* Tubing. 1814. Jaeger, in Meckel's *Archives,* s. 113; and Leuckart, vol. vi. s. 136.

† The same fact was observed by Seger, in the latter vessel in the seal, of which he has given an account in the *Ephem. Nat. Curios,* Dec. 1, an 9, p. 252.

The question, whether or no the *foramen ovale* be open in such animals as have the power of diving, and remaining for some time under water, seems to be as yet not completely decided. In addition to the affirmation of the author the evidence of Cuvier may be quoted; he states that in several *porpoises*, in a *dolphin* and a *seal*, he found this opening closed. (*Léçons d'Anat. comp.* tom. iv. p. 201.) The Parisian dissectors also found it closed in a *beaver*. (*Description Anatom. d'un castor*, &c. p. 68.) It has been found perfectly shut in a *porpoise* and young *seal;* and according to Sir Everard Home, (*Phil. Trans.* 1802) it is closed in the *ornithorhynchus.* On the other side of the question, besides the fact mentioned by Blumenbach, which is very striking, we may adduce Sir Everard Home's authority for the existence of the foramen ovale in an open state in the *sea otter.* He found it so in two instances, one of which was in an adult animal; but the *ductus arteriosus* was closed. (*Philos. Trans.* 1796, pt. 2.) This may perhaps be nothing more than a casual occurrence; as a small opening is not unfrequently found in the human subject, where no symptom of disease, or defect in the circulating system has existed.

§ 161. There are some remarkable circumstances in the distribution of particular arteries in certain animals of this class. We may notice, as the most singular of these, the rete mirabile, formed by the internal carotid at its entrance into the cranium, in several ruminating *bisulca*† and *carnivorous animals;* and that division of the arterial trunks of the extremities, which has been observed by Sir A. Carlisle‡ in the slow-moving animals, viz. the *sloths* and *lemur tardigradus.* The arteries of the arm and thigh in these cases divide, as they leave the trunk, into numerous parallel branches, which are united again towards the elbow and knee. The most curious and elegant distribution of veins occurs in the foot of the horse; where these vessels run in innumerable parallel branches on the anterior surface of the coffin bone, and form a reticular plexus of anastomoses on the under part which completely covers the surface of the bone.

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* Kulmus, in the *Acta Acad. Natur. Curios.* tom. i. p. 25.

† It is represented by Monro in the slink calf. *Obs. on the Nervous System,* tab. 1.

‡ In the *Philos. Trans.* for 1800, p. 98.

Plexuses or convolutions of the arteries are found in some parts of the *cetacea;* as in the intercostal arteries, in the branches which go from the subclavian to the chest, and in those which supply the medulla spinalis and the eye. Hunter in the *Philos. Trans.* 1789, pt. 2.

BIRDS.

§ 162. The whole of this class, without exception, possess a very remarkable peculiarity in the structure of the heart. The right ventricle, instead of having a membranous valve, (such as is found in both ventricles of mammalia, and also in the left of birds) is provided with a strong, tense, and nearly triangular muscle. This singular structure assists in driving the blood with greater force from the right side of the heart into the lungs: since the expansion of the latter organs by respiration, which facilitates the transmission of the carbonated blood in mammalia, does not take place in birds, on account of the connexion which their lungs have with the numerous air-cells, which will be afterwards described.*

§ 163. To this class, and also to those of amphibia and fishes, Professor Jacobson ascribes a peculiar venous system, by which the blood is carried from the posterior extremities and from the sexual organs, not, as in mammalia, to the posterior vena cava, but to the kidneys, or to the kidneys and liver, for the purpose, as it should seem, of secreting the urine in these three classes.†

AMPHIBIA.

§ 164. The frogs, lizards, and serpents, of this country at least, (Germany) have a simple heart, consisting of a single ventricle and auricle.* In others, as for instance crocodiles and lizards, properly so called, and serpents, the heart consists of one ventricle with two auricles.

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* I have entered more largely into this subject, in the *Comment. Reg. Soc. Scient.* Gotting. vol. ix. where there is also a representation of the muscle in the heron, p. 128.

† See the *Bulletin de la Soc. Philom.* 1813. Meckel's *Archives,* vol. iii. s. 147; and *De Systemate venoso peculiari.* Hafn. 1821.

The account which Cuvier gives of the anatomy of the heart in the *amphibia*, does not exactly accord with that of the author. Cuvier describes and delineates the heart of the *crocodile* as being formed nearly like that of the *turtle* (tom. 5, pl. 45); he says that the *iguana* has a similar structure, and that it obtains likewise in the serpents (tom. v. p. 221-225). He does not mention the more simple form as existing in any *lizard* or *serpent*.

§ 165. The structure of this part is very different in the turtle; and has given rise to more controversy than that of any order of animals. The heart of this animal possesses two auricles, which are separated by a complete septum, like those of warm-blooded animals, and receive their blood in the same manner as in those animals; viz. the two venæ cavæ terminate in the right auricle, the pulmonary veins in the left. Each pours its blood into the corresponding ventricle, of which cavities there are two; thus the structure of the heart hitherto resembles that of mammalia.

A remarkable difference exists in the structure of the auricles between the *testudo caretta* and *mydas*, both of whose hearts now lie before me. The auricles of the former are thin, like those of warm-blooded animals; in the latter they are very firm, and have almost as thick and strong parietes as the ventricles.

The characteristic peculiarities which distinguish the heart of these animals consist in three circumstances. First, the two ventricles (and in some species of *turtles*, the cavities of the auricles) are extremely small and narrow, but the fleshy walls of this viscus are of a thick and spongy texture, so that the heart has the appearance not so much of a double visceral sac, as of a sponge soaked with blood. Secondly, both the ventricles communicate with each other; there is a muscular, and as it were tubular valve, going from the left to the right cavity, by means of which the former opens into the latter. Thirdly, the large arterial trunks arise all together from the right ventricle only; no vessel coming from the left. The aorta, with its three principal branches,[*] is situated towards the right side and the upper part; the pulmonary artery comes as it were from a particular dilatation of the right ventricle,[†] which is not situated nearly in the middle of the basis of the heart; (it must be understood, as we have already observed, that we apply these terms according to the horizontal position of the animal).

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* Swammerdam gives the clearest representation of the heart of the frog, and of the vessels which are most immediately connected with it, tab. 49.

We can now comprehend how this wonderful and anomalous structure, by which all the blood is propelled from the right ventricle only, is accommodated to the peculiar way of life of the animal, which subjects it frequently to remaining for a long time under water. For the greater circulation is so far independent of that which goes through the lungs, that it can proceed while the animal is under water, and thereby prevented from respiring, although the latter is impeded. In warm-blooded animals, on the contrary, no blood can enter the aorta, which has not previously passed through the lungs into the left ventricle; and hence an obstruction of respiration most immediately influences the greater circulation.

The best and most intelligible delineations of the turtle's heart are those given by Mery;[‡] although he made an erroneous application of them to the course which he supposed the blood to take in the heart of the human fœtus. I conclude from a comparison with my own preparations, that his drawings were taken from the *testudo caretta.*

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[*] Two of these go to the abdomen; the right is the proper *aorta abdominalis;* the left is the *ductus communicativus* of Mery, who compared it to the *ductus arteriosus* of the fœtus.

[†] Mery and Morgagni considered this dilatation as a third ventricle, *ventriculus intermedius*; hence it has happened, that some zootomists have ascribed to the turtle a single ventricle, (on account of the communication); some two, and others three.

[‡] *Mém. de l'Acad. des Sc.* 1703. See also Morgagni's excellent account of the heart of the tortoise, in his *Advers. Anat. V. Animalium,* from which he draws the following correct inferences. *Quæ cum ita sint, agnovi facile, sanguinem tum ab universo corpore, tum a pulmonibus redeuntem, illum quidem per auriculam dexteram immediate, hunc vero per sinistrum, subjectumque sinistrum ventriculum, omnem denique in dextrum compelli, ut ab hoc, et communicante intermedio tum in corpus universum, tum in pulmones propellatur.* 'From these circumstances I ascertained that the blood which returns from the whole body, as well as that which returns from the lungs (the former immediately by the right auricle, and the latter by the left auri-

The natural structure of the hearts of these animals has a striking analogy with the unnatural condition of this organ in persons born with the *morbus cœruleus.* This phenomenon with many others tends to shew that certain organs of the human embryo, as well as the whole of its earliest formation, are subjected to a kind of metamorphosis, the embryo first resembling the structure of the lower classes of animals, before it reaches the perfection of the human type. If during this change the completion of any organ should be interrupted by any accidental disturbance of the formative impulse, it remains in a state which has a greater or less resemblance to that of an inferior organization. Hence in many persons affected with the blue complaint, the ventricles communicate with each other by an opening in the septum, and both arteries arise from the right, and none from the left.*

FISHES.

§ 166. The heart in this class of animals is extremely small in proportion to the body. Its structure is very simple, as it consists of a single auricle and ventricle, which correspond with the right side of the heart in warm-blooded animals.† The ventricle gives rise to a single arterial trunk (which is expanded in most fishes into a kind of bulb as it leaves the heart), going straight forwards to the *branchiæ,* or organs of respiration. The blood passes from these into a large artery, analogous to

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cle, and the left ventricle beneath it) was driven to the right ventricle, to be propelled from it, and the intermediate one communicating with it to the whole body, as well as to the lungs.

* Abernethy's *Surgical and Physiological Essays,* part ii. p. 158.

Jo. Conr. Tobler *De Morbo Cæruleo.* Gotting, 1812, 4.

J. C. Hein *De istis Cordis Deformationibus quæ sanguinem venosum cum arterioso misceri permittunt.* Gott. 1816, 4.

† See Tiedemann's *Anatomie des Fischherzens.* Landshut, 1809.

the aorta, which goes along the spine and supplies the body of the animal; it is then returned by the venæ cavæ into the auricle;* a proof, among many others, of the power which the arteries possess of returning the blood, independently of the action of the heart.

§ 167. Most cold-blooded animals, as fishes, and the amphibia of this country, (Germany) have a much smaller proportion of blood, and fewer blood-vessels than those with warm blood. On the contrary, they have a much greater number of *colourless vessels* arising from the arterial system.

INSECTS.

§ 168. A true heart, and system of vessels connected with it, are found in a very few of what are called white-blooded animals. In this class they seem to belong only to some genera of insects, which have no wings; as the genus *cancer*,† and *monoculus*. It has been proved by the excellent investigations of Herold,‡ that the long dorsal vessel of the larvæ, &c. communicating an undulating pulsation, and carrying a kind of ichor, is protected on each side by a flat triangular muscle, and that it is an organ analogous to the heart. In the genera which we have mentioned, there seems to be no passage of the arterial extremities into the origins of veins, and consequently no true circulation.

It appears that insects possess neither blood-vessels nor absorbents. Cuvier has examined, by means of the microscope, all those organs in this class, which in red-blooded animals are most vascular, without discovering the least appearance of a blood-vessel; although extremely minute ramifications of the tracheæ are obvious in every part. And Lyonet has traced and delineated in the caterpillar parts infinitely smaller than the chief blood-vessels must be, if any such existed. *Anatomie de la Chenille*, &c.

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* Representations of the heart of a fish are given by Perrault, in the *Essais de Physique*, tom. iv. tab. 19; by Duverney, in his posthumous *Œuvres Anatomiques*, tom. ii. tab. 9; by Gouan, *Historia Piscium*, tab. 4, (all these however call the trunk of the *branchial artery*, the *aorta*); and by Monro, in his *Structure and Physiology of Fishes;* and above all Tiedemann, in the work above cited.

† Willis *De Anima Brutorum*, tab. 3, fig. 1. Rösel's *Insectenbelastigungen*, vol. iii. tab. 58; and Treviranus *über den innern Bau der Arachniden*, s. 16.

‡ *Uber das Rückengefass der Insecten*, in the *Abhandl. d. Naturforsch. Ges. zu Marburg*, b. i.

Yet insects, both in their perfect and in their larva state, have a *membranous tube* running along the back, in which alternate dilatations and contractions may be discerned. From this circumstance it has been supposed to be the heart; but it is closed at both ends, and no vessels can be perceived to originate from it.

It is obvious from these data, that the functions of nutrition and secretion must be performed in the animals which we are now considering, in a very different manner from that which obtains in the more perfect classes. Cuvier expresses the mode, in which he supposes growth and nutrition to be effected, by the term "*imbibition*." And he explains from this circumstance, the peculiar kind of respiration which insects enjoy. Since the nutritive fluids have not been exposed to the atmosphere, before they arrive at the parts for whose nourishment they are destined; this exposure is effected in the parts themselves by means of the air-vessels, which ramify most minutely over the whole body. "En un mot, le sang ne pouvant aller chercher l'air, c'est l'air qui va chercher le sang." (*Leçons d'Anat. comp.* l. xxiii. sect. 2, art. 5.)

The heart of the *crustacea*, according to Cuvier, has no auricle, and it is what he calls an *aortic heart*. For it expels the blood into the arteries of the body, and this fluid passes through the gills previously to its reaching the heart again. The different parts of the system are here found under a mode of connexion exactly the reverse of what we observe in fishes, where the blood is sent into the gills, and passes subsequently into the aorta. The circulating organ in that class is therefore a *pulmonary heart*.

VERMES.

§ 169. In many genera of this class, particularly among the *mollusca*,[*] and *testacea*,[†] there is a very manifest heart,[‡] which is sometimes of a singular structure. It consists, for instance, in the *cuttle-fish*, of one ventricle, and two auricles, which lie at some distance from the ventricle, near the gills. Some bivalves are said by Poli to have two auricles, and some even four. But in all these crustaceous animals, there has been no connexion hitherto discovered between the arteries and veins;* while on the other hand some genera in other orders of this class have a connected system of vessels without a heart;† and the proper *zoophytes* cannot be said to possess either; as their nutrition seems to be effected by an immediate derivation of the nutritive fluid from their abdominal cavity into the gelatinous parenchyma of their body.

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[*] See Swammerdam, of the *Limax Maximus*, tab. 9, of the *Sepia Officinalis*, tab. 52. Monro, *On Fishes*, tab. 31. Cuvier, *Tableau Elémentaire de l'Histoire Naturelle des Animaux*, tab. 8, fig. 1. Home, *Phil. Trans.* 1817; and of the *Aplysis Fasciata*. Cuvier, *Mollusques*, tab. ii, fig. 3.

[†] See Poli, *Testacea utriusque Siciliæ*, vol. i. and ii. for a representation of this in several testacea. Willis, in the work above quoted, tab. 2, of the *Oyster*. Swammerdam, tab. 5, of the *Helix Pomatia*. Stiebel, of the *Helix Stagnalis*.

[‡] Cuvier divides the whole class of *vermes*, according as they are furnished with a heart and vascular system, or are destitute of these organs, into two families; the former he calls *mollusca*, the latter *zoophyta*.

Baker, Fontana, Muller, and several other excellent naturalists, have considered the dark portion in the body of the wheel animal (*vorticella rotatoria*) to be a heart; although it has voluntary motion, which is influenced by that of the radii, and they have employed this circumstance by a curious *petitio principii*, to prove that there are animals which have a voluntary power of setting their heart in motion, or leaving it at rest. I have shewn twenty-three years ago‡ that this remarkable organ can by no means be looked upon as a *heart*, but is really an *alimentary canal*.

According to Cuvier, the cuttle-fish has three hearts, neither of which possesses an auricle. Two of these organs are placed at the root of the two *branchiæ;* they receive the blood from the body (the vena cava dividing into two branches, one for each lateral heart) and propel it into the branchiæ. The returning veins open into the middle heart; from which the aorta proceeds.

The other *mollusca* have a simple heart, consisting of one auricle and ventricle. The vena cava assumes the office of an artery, and carries the returning blood to the gills; whence it passes to the auricle, and is subsequently expelled into the aorta. Here therefore, as in the crustacea, the heart is a *pulmonary* one.

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* See Poli, tom. ii. tab. 25, of the *Arca Noæ,* and tab. 27, of the *Ostrea Jacobæa,* also tom. i. introduction, p. 39.

† B. F. Bening *De Hirudinibus.* Harderov. 1776, 4to. a very excellent monograph. The *medusæ* also have no heart, but a manifest circulating system of arteries and veins. See Mitchell, in Albers's *Americanischen Annalen,* p. 121.

‡ The author completed his seventy-third year in the month of Sept. 1825; when many of the most distinguished physiologists and men of letters in Germany came to Göttingen for the purpose of celebrating a sort of philosophical jubilee in honour of their distinguished countryman.

The *vermes* of Cuvier have circulating vessels, in which contraction and dilatation are perceptible; without any heart. They can be seen very plainly in the *lumbricus marinus*. The *leech*, *naias*, *nereis*, *aphrodite*, &c. are further examples of the same structure. This anatomist is of opinion that the *mollusca*, *crustacea*, and *vermes*, possess no absorbing vessels; and he thinks that the veins absorb, as he finds them to have communication with the general cavity of the body, particularly in the cuttle-fish. Hence the above-mentioned classes will hold an intermediate rank between the *vertebral animals* which possess both blood-vessels and absorbents, and the *insects* which have neither. (*Leçons*, &c. l. 23, sect. 2, art. 4.)

The comparison of the circulating system in different classes of animals constitutes one of the most interesting and important branches of investigation in the study of comparative anatomy; and the student should bear in mind that it was in the course of his inquiries into the structure of the lower animals, that the immortal Harvey was led to the discovery of the circulation of the blood. Much valuable information on this subject will be found in the lectures of Sir E. Home, from which work we extract the following observations.

In animals that have no vascular system, consisting solely of a membranous bag, there is much reason to believe no waste of materials takes place while in a quiescent state; indeed the facts which Mr. Bauer has published in the *Philos. Trans.*, respecting the worms that form the disease in wheat called by farmers the purples, of which Sir E. Home has taken notice in the first volume of his Comparative Anatomy upon the Digestive Organs of Worms and Insects, completely establishes this fact. Mr. Bauer has preserved some of these worms in a dried state, and has found, that although they have been kept so for six years, and even longer, when moisture is applied to them, and they are placed in the field of the microscope, they revive in five or six hours, and move with great agility.

The animals next in order to these worms, are other genera of vermes, in which there is a circulation, but no heart: of this kind are all caterpillars and insects. In them the blood does not circulate, and probably remains at rest at those times in which the animal is in a quiescent state; but during the period of locomotion, or when feeding, or using other muscular exertion, the blood undulates from one end to the other of a large tube situated upon the back, at such times supplying the different organs, and becomes aerated by the air-vessels which pervade every part of the body.

Were animals classed according to the different modes of aerating the blood, one great class might be formed of those animals, in which the air circulates through the body, and the blood is confined to a reservoir; another, when the blood circulates through the body, and the air is only applied to a particular portion of it.

The heart will therefore be found to be of less importance than it has been generally considered, and only to be an organ met with in some of the higher orders of animals.

When we consider the aeration of the blood in insects, it must be greater than in other animals ; and there is this curious circumstance, arising out of the bodies being so abundantly supplied with air, as soon as the cold is too great for their exerting muscular power, the spiracula become closed, and the animal remains in a torpid state ; by any increase of the warmth of the atmosphere, the air retained in the tubes is rarefied, the external orifices of the spiracula are forced open, and the functions of life are again carried on.

This fact is not to be doubted, since we see the same thing take place in the *vermes*, when they shut up for the winter. The *garden-snail*, as soon as the cold weather sets in, fixes itself upon any hard substances, by throwing out a slime which cements the open edge of the shell to the surface, and the snail remains there during the winter-months ; all the organs of the body being in a state of rest.

When warmth and moisture are applied, the membranous film falls off; a globule of air that remained in the cavity of the lungs becomes rarefied, and forces its way out, and admits of fresh air being applied to these organs.

In animals in which the circulation of the blood is carried on by means of a heart, the blood is aerated in very different proportions.

The *aphrodite aculeata* has, properly speaking, no blood-vessels; the water is received by thirty-two lateral openings between the feet, into the cavity under the muscles of the back, and there applied to the surfaces of the projecting cells, of which there are two rows, fifteen in each ; through these the air in the water is communicated to the cœca contained in them, which Sir E. Home considered to be the respiratory organs.

In the *leech* there is no heart, but a large vessel upon each side of the animal; and the water is received through openings into the belly, into the cells or respiratory organs, and passes out through the same.

In the *earth-worm* there is an artery that passes up the back, and a corresponding vein passing down from the head upon the middle of the belly ; near the head, there are five pair of lateral canals that swell out beyond the size of the large vein, so that they become reservoirs of blood to supply the vessels of the head, when wanted to bore through the earth, and the action of the muscles so employed will, by their situation, accelerate the circulation. The œsophagus, lying in the center of these reservoirs, will, by the action of its coats while the animal is eating, have an influence on the circulation. The blood is aerated by lateral cells in the same manner as in the *leech*.

In the *muscle*, the gut passes through the heart, which is an oval bag, having no auricle, unless the two large veins are called such ; the coats of the ventricle are very thin, but the action of the intestine makes up for this deficiency.

In the *earth-worm,* the circulation is properly in a circle without beginning or ending. One vessel runs upwards to the head, along the back, communicating with the lateral reservoirs, but still a continued tube goes on. It is the same with the vein or opposite vessel that runs down the tail, and the branches that go from the artery to the lateral cells, have corresponding branches returning the blood to the great vein. This may be considered as one mode of circulation peculiar to this tribe; and it is admirably contrived that the blood may be accelerated in its motion by the muscular action of the body of the animal, without any increase of action in the arterial system.

The aeration of the blood in this mode of circulation is imperfect, only one portion being aerated and mixed with the rest, in which no such changes have been produced.

In the *lumbricus marinus,* although the principle of the circulation is the same, there are many strongly marked differences in the mode of carrying it into effect.

There is, as in the *terrestris,* one trunk behind, going from the tail to the head, and one from the head to the tail on the belly, completing the circle; but in this animal there are external gills, which remain protruded while the animal is in the water, and the blood has such a velocity in these vessels, that they may be considered as so many small ventricles; this is an approach to the construction of the gills of the *sepia.* In this circulation there are two regularly formed auricles, supplied by lateral veins from the viscera attached to the sides of the great artery, so as to increase the supply of the blood, and afford quantity as well as velocity; while it gives off branches to the gills, the main trunk pursues its course, supplying the body. In this animal, it is only a portion of the blood which is aerated, and from the structure of the gills that must be in a much greater degree than in the *lumbricus terrestris.*

The animal whose heart is nearest in structure to those described is the *oyster,* in which the whole blood is aerated in passing through the gills, before it is received into the auricle. In this animal, the auricle and ventricle are very thin in their coats, so much so as to make them unequal to apply force to the blood; but the ventricle is laterally connected to the great muscle, whose action will accelerate the circulation.

In the *toredo navalis* the heart is situated upon the back of the animal near the head, consisting of two auricles of a thin, dark coloured membrane; the auricles open by contracted valvular orifices into two white stony tubes; those united form the ventricle which terminates in an artery that goes to the bony shell. The heart is loosely attached; its action is distinctly seen through the external covering and in some instances continues to act after it is laid bare.

The first contraction is in the two auricles, which are shortened in that action, this enlarges the ventricle before it contracts. The great artery from the ventricle goes directly to the head, and the vessels that supply the auricles are seen to come from the gills. The auricles are lined with a black pigment, so that their contents cannot be seen through their coats; and the ventricle from its thickness is not transparent, but the muscles of the boring shells are of a bright red, and all the parts between the heart and head are supplied with red blood.

The structure of the heart is different from that of the *lumbricus marinus*, and consequently the circulation is by no means peculiar.

This animal's heart may be said to be the first in this series that is complete, and this first regular circulation of the blood, every part of which passes through the vessels of the gills, and even through the cavities of the heart. As this animal is to work a machine capable of boring a very hard substance, and to go on working during the whole of that period of life in which its growth is continued, to make room for the increased bulk, so it requires that the blood be more highly aerated and supplied with greater velocity to these active organs. The heart also, to give it greater advantage in these respects, is placed near to the boring shells, so that the blood which goes to them, is of the brightest colours.

In this circulation the first action of the heart is to supply the different parts of the body with aerated blood; upon this the activity of the heart is wholly exerted; the blood is returned more slowly through the gills, and remains there a longer time, so as to receive a greater degree of the influence from the air contained in the water.

This is the principle on which the circulation of many of the *vermes* is established, and is exactly the reverse of what takes place in fishes, reptiles, and the higher orders of animals.

The mode in which the breathing organs of the *toredines* are supplied with water, makes it evident that all *sea-worms* which have no cavity for the reception of sea-water, must have the breathing organs placed externally, as is the case with all those species of *actinia* met with in the West Indies, called *animal flowers*, and the beautiful membranous expansions they display, resembling the petals of flowers, are in fact the breathing organs acting at the same time as tentacula.

In the *sepia* this mode of circulation is rendered more complex, but the same principle is adhered to. In the *toredines* the water is intimately applied to the gills from the simplicity of their structure; but in the *sepia* they are more complex, and require force to apply the water to every part of them, and for this purpose there is a bulb and double valve placed at the roof of each gill.

In the *sepia* the blood is brought to the gills from all parts of the body by three sets of veins, all branching off from the trunk of the vena cava. The common trunk that goes to each gill, is of so large a size and so thin in its coats, that to prevent the regurgitation of the blood, the valve is interposed; the blood having got into the gills, and having pervaded every part of the branchiæ, it is conveyed by a smaller trunk to the auricle, so that the gills will never be completely emptied; it is then received into the ventricle, and carried into every part of the body. The circulation is also similar in the *lamprey*, *lampores*, the *myxene*, and an animal nearly allied to it from the South Seas, which has never received a specific name, although there are peculiarities in the gills from which these animals must be considered in their aeration inferior to fishes at large.

In the *lamprey* and *lampern*, the water is received by the seven lateral openings on each side of the animal into the bags that perform the office of gills, and passes out by the same orifices, the form of the cavities being such as to allow the water to go in at one side and out at the other, after having passed over all the projecting parts. Some of the water escapes into the middle tube, and from thence passes out either into the other bags or at the upper end into the œsophagus.

The muscular structure of the branchial artery of the *dog-fish*, and the direction in which that artery leaves the ventricle, are exactly the same as in the *squalus maximus*, only they are seen on so small a scale, that they do not arrest our attention; but when magnified to the same size which they acquire in this fish, they make a stronger impression upon the mind, and force us irresistibly to inquire after their use. The direction of the artery appears to be common to fishes in general, but the muscular structure that is met with in the branchial artery, is confined to particular tribes. Sir. E. Home met with it in the *sturgeon*, and says it is common to *sharks*.

In the *wolf-fish*, the *anarhichus lupus*, the muscular structure of the branchial artery is nearly the same, but the valves are placed close to the opening of the ventricle, and only two in number. In the *turbot* there is no muscular structure in this part, but the coats are extremely elastic, and admit of being very considerably dilated, particularly at its origin, where three valves are placed, and so contrived, that the dilatation of the artery makes them shut more closely.

In the *lophius piscatorius* there is no appearance of muscularity in the coats of the branchial artery, and no lateral valves, as in other fishes; but there is a muscular tube half an inch long, rising from the edge of the opening of the ventricle, which projects into the artery.

These different structures, so unlike one another, and bearing no resemblance to the mechanism in the same parts in quadrupeds, make it probable that the circulation through the gills is impeded by the external pressure of the water in different degrees according to the depth of the fish from the surface; therefore in those fishes which frequent the great depths, as the *squalus*, in all its tribes, there is a muscular structure in the coats of the branchial artery, which, when the fish is deep in the water, by its contraction diminishes the area of the vessel, and makes the valves perform their office; but when the fish is near the surface, this muscular structure, by its relaxation, renders the area of the artery so wide, that regurgitation of the blood takes place into the ventricles, and prevents the small vessels of the gills from being too much loaded.

That such regurgitation can take place when the muscle is relaxed, is ascertained by the ventricle being readily injected after death with coarse injection from the artery, the valves allowing it to pass.

In fishes that swim deep and do not come to the surface, as the *wolf-fish*, the regurgitation does not take place into the ventricle; but the relaxation of this muscular portion of the artery allows it to dilate and form a reservoir, and the valves remain closed so as to prevent more blood leaving the ventricle.

In fishes residing at moderate depths, as the *turbot,* elasticity is employed as a substitute for muscular powers, there being less variation. In the *lophius piscatorius*, which probably never descends into water of great depth, the ventricle is so weak that the supply of blood to the gills is regulated by the contraction and relaxation of a muscular valve.

The heart of the *manatee*, or *dugong* of the West Indies, has its ventricles completely detached from each other: when we compare this with the heart of the *whale tribe*, we find that the right ventricle in the *whale* is a nearer approach to the left than in the quadruped.

The ventricles in the *dugong*, although similar in structure, are not exactly of the same size. The left is thickest, and half an inch longer.

The auricles resemble those of the *whale*, having the same transverse ligamentous bands.

The valves had nothing particular in their appearance.

The foramen ovale was entirely closed, but its situation was distinctly seen.

The relative size of the aorta and pulmonary artery was the same as in the *elephant*.

CHAPTER XIII.

OF THE ABSORBING VESSELS.

§ 170. It was regarded as an axiom even by Valsalva, that those animals, which have true blood-vessels, have also an absorbing or lymphatic system. It appears also that the converse of this proposition is true: viz. that those classes only have true lymphatic vessels, which possess at the same time a perfect circulating system of blood-vessels; that is, only the four classes of red-blooded animals.

In many of what are called white-blooded animals, there is a kind of absorption very evident; as in the armed polypes, whose parenchyma becomes tinged in a short time with the colour of those insects which have been swallowed. The existence of absorption is inferred by analogy from other phenomena, as the metamorphosis of *larvæ*, &c. But no true system of real absorbing vessels has been hitherto demonstrated in these animals.*

§ 171. This system (which comes most properly under consideration in the present chapter, on account of its relation to the circulation of the blood) consists of the *lacteal* vessels, which arise from the small intestines, and of the proper *lymphatic* vessels, which belong to the rest of the body. It includes also the *conglobate glands*, which are found in most of the animals which have this system, and seem to consist merely of a congeries of vessels; and lastly, the *thoracic duct*, which is the chief canal for conveying the fluids from the lymphatic system into the blood.

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* Sheldon has ascribed absorbing vessels to the *silk-worm* and other *larvæ*. See his history of the absorbent system, part i. p. 28; and Monro to the *echinus esculentus*, (sea hedgehog) in his *Physiol. of Fishes*, p. 88.

The structure and offices of the absorbent glands have been illustrated by the observations of Mr. Abernethy on the formation of these parts in the whale. He found the mesenteric glands of that animal to consist of large spherical bags, into which several of the lacteals opened. Numerous vessels ramified on these cysts; and the injection passed from their secerning extremities into the cavity. In the groin and axilla of the horse he also found them to consist of one or more cells. Hence there can be no doubt that the absorbed fluid must receive an addition in its passage through these bodies. *Philos. Trans.* 1796, pt. 1.

It has been much questioned whether the lymphatics have any communication with the venous system prior to the termination of the thoracic duct. The observations of that ingenious veterinary surgeon, Mr. Bracy Clark, have determined this question in the affirmative; as he has found the trunk of the lymphatic system to have several openings into the lumbar veins in the horse. Rees's *Cyclopædia,* article Anatomy Veterinary.

The communication of the lymphatics with the veins in the four classes of vertebrated animals has of late years been demonstrated by Lippi, Fohmann, and Lauth, and in the anatomical museum of Heidelberg there are numerous beautiful specimens shewing this fact.

MAMMALIA.

§ 172. All the parts of the absorbing system, which have been just enumerated, are most perfect and manifest in this class of animals: it is well known indeed that all the chief parts of this important system of vessels have been first discovered in mammalia. When their lacteals contain chyle, they are distinguished by their white colour from the other absorbing vessels, the contents of which are either limpid, or of a slight yellow tinge. The former vessels run together in considerable trunks, particularly in the *sheep* and *goat:* the latter, or true lymphatics, may be seen to advantage on the hind-leg of the *horse,* where they follow a tortuous course.

The thoracic duct is double in some quadrupeds,* as in the *dog,* and forms at its commencement, more constantly than in the human subject, a vesicular enlargement, called the *cisterna,* or *receptaculum chyli.* The course and distribution of the thoracic duct vary in quadrupeds, at least in our domestic animals, as much as in the human subject. It forms, not unfrequently, in the *dog* a kind of annular portion at its upper, or more properly anterior end; which trivial variety Van Bils transformed into a constant and important circumstance, and called "*receptaculum tortuosum.*"*

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* Pecquet, *Experimenta Nova Anatomica,* p. 21, ed. of 1654.

In many mammalia, particularly of the order *feræ*, the mesenteric glands are collected into one mass, which is known by the inappropriate name of *pancreas Asellii.*†

Sir Everard Home has found that in the *sea-otter* the receptaculum chyli sends two trunks to form the thoracic duct. These have frequent communications; so that there are sometimes three, frequently four, and never fewer than two trunks running parallel to each other. *Philos. Trans.* 1796, pt. 2.

BIRDS.

§ 173. The chyle is transparent in this class; therefore the lacteals are only distinguished from the lymphatics by their situation and office. There are no glands in the mesentery, although conglobate glands are found in other parts in several of the larger birds. Their thoracic duct is double.‡

In a communication made to the Academy of Medicine at Paris in 1819, M. Magendie denied the existence of lymphatics, with few exceptions, in the class of birds. He dissected more than fifty birds of different kinds, and was not enabled to discover the lymphatics in any part of the body except in the neck of the swan and goose; in this part he found the lymphatics and glands as in mammalia, filled with a diaphanous and colourless lymph. The opinion of Magendie has been satisfactorily refuted by several anatomists, particularly by Dr. Lauth of Strasburg, who, in an excellent treatise, entitled *Mémoire sur les vaisseaux Lymphatiques des Oiseaux et sur la manière de les preparer*, has proved the existence of lymphatics in birds.§

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* He has represented it in a very beautiful plate, as far as the engraving goes, in his *Responsio ad Admonitiones*, Jo. Ab. Horne. Roterod. 1661, 4, p. 7.

† Asellius *De Lactibus*, tab. 1 and 2.

‡ Hewson, in the *Phil. Trans.* vol. lvii. tab. 10, of the *cock.* See also Magendie, in his *Journal de Physiologie Expérimentale*, tom. i. 1821.

§ See the work recently published by Fohmann, *Teacher of Anatomy at Liege*, en-

AMPHIBIA.

§ 174. Lacteals are found in great number in the delicate mesentery of the turtle. The thoracic duct is double. There seem to be no lymphatic glands at all.*

The distribution of the lymphatics on the intestine of the turtle forms one of the most elegant preparations in comparative anatomy. By fixing the injecting tube in a vessel near the intestine, and waiting with a little patience, the quicksilver will gradually find its way into the minute ramifications of the lacteals. The peritoneal surface of the gut is covered with very minute straight parallel branches, running according to the length of the intestine. Its inner surface is no less thickly covered with lacteals of a different appearance. When dried it seems as if the quicksilver were contained in small cells, covering the whole internal surface of the intestine so completely that the point of a pin could scarcely be placed between them.

FISHES.

§ 175. The lymphatics of these animals seem to be destitute of glands and valves: they want also the lymphatic glands, and their thoracic duct divides, at least towards its anterior part, into two chief branches.†

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titled *Das Saugader System der Wirbelthiere Von. Vin. Fohmann, Das Saugader System der Fische.* Heidelb. and Leips. 1827, representing the lymphatics of the stomach, liver, spleen, intestines, genital organs, and fins, as well as the thoracic duct of the *gymnotus electricus, eel, pike,* &c. Professor *Fohmann* has announced his intention of delineating and describing the lymphatics in the other classes of vertebrated animals in a future publication.

* Monro's *Physiol. of Fishes,* tab. 30.

† Hewson and Monro, in the works quoted above. See also Bartholin, *Anat. Renov.* p. 609, of the *cyclopterus lumpus* (lumpsucker).

CHAPTER XIV.

ON THE ORGANS OF RESPIRATION.

§ 176.* The incessant continuation of the great chemical process by which *oxygen*, the true pabulum vitæ, is exchanged for *hydrogen* and *carbon*, is essentially necessary to the well-being of the greater part of animals. Yet the organs and mechanism by which this wonderful function is carried on vary very considerably.† In the mammalia after birth; in birds, when they have left the egg; and in amphibia when completely formed, the chief organ of this function is the *lungs;* in fish it is performed in the *gills;* in most insects in their *tracheæ;* in the vermes, in analogous, but at the same time very different parts.

MAMMALIA.

§ 177. The lungs of quadrupeds agree on the whole in structure, form, and connexion, with those of the human subject. In the *cetacea*, on the contrary, and in the web-footed mammalia, (as the *manati*) which approach most nearly to them, they are distinguished by a firmer texture, particularly of the investing membrane, and by their peculiar form; since they are not divided into lobes, but have an elongated and flattened appearance. They are adherent to the pleura, as well as to the very strong and muscular diaphragm.*

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* Much instructive information on the respiratory system in different animals may be found in Geoff. St. Hilaire, *Philosophie Anatomique*. Par. 1818.

† Aug. Broussonet *Variæ Positiones circa Respirationem*. Monspel. 1778, 4; also Ludwig's *Delectus Opusculor. ad Scient. Naturalem spectant.* Lipsiæ, 1790, 8, p. 118.

Chr. L. Nitzsch *De Respiratione Animalium*. Viteb. 1808, 4.

G. J. Van Der Boon Mesch *De Circulatione et Respiratione Animalium Pulmonibus instructorum*. Leid. 1812, 4.

Fouquet *De Organi Respiratorii in Animalium serie evolutione*. Jen. 1818, 8.

A. F. Schweigger's *Classification der Thiere nach den Respirations-Organen, im Königsberger Archiv. für Naturwiss.* etc. i. th. p. 90.

BIRDS.

§ 178. The respiratory organs of this class constitute one of the most singular structures in the animal economy, on account of several peculiarities which they possess; but more particularly in consequence of their connexion with the numerous air-cells which are expanded over the whole body.†

The lungs themselves are comparatively small, flattened, and adherent above to the chest, where they seem to be placed in the intervals of the ribs; they are only covered by the pleura on their under surface, so that they are in fact on the outside of the cavity of the chest, if we consider that cavity as being defined by the pleura; a great part of the thorax, as well as the abdomen, is occupied by the membranous air-cells,‡ into which the lungs open by considerable apertures. Those of the thorax are divided, at least in the larger birds, by membranous transverse septa into smaller portions,§ each of which, as well as the abdominal cells, has a particular opening of communication with the air-cells of the lungs, and consequently with the trachea. The membranes of these cells in the larger birds are provided here and there with considerable fasciculi of muscular fibres, which have been regarded as a substitute for the diaphragm, which is wanting in this class of animals.‖ They also serve very principally, as we may ascertain by examining large birds in a living state,[*] to drive back again into the lungs the air which they received in inspiration, whence the repletion and depletion of the thoracic cells must alternate with those of the abdominal cavities.[†]

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* Tyson's *Anatomy of a Phocæna,* p. 30.

† Ladisl. Chernak *De Respiratione Volucrum,* 1773, 4to. Fuld *De Organis quibus Aves spiritum ducunt.* Wirceb. 1816. Harvey *De Generat. Animal.* 1651.

‡ Discovered by Harvey, *De Generatione Animalium,* p. 4.

§ Perrault, *Essais de Physique,* tom. iii. tab. 18, of the ostrich.

‖ Casp. Bartholin *Diaphragmatis Structura Nova.* Paris, 1676, 8, p. 31. Modern zootomists have been divided on the question, which of the membranes, in or about

The cartilaginous annuli of the trachea, which are in general more complete in the other mammalia than in man, are perfect circles in birds, and overlap each other at their upper and lower margins. Hence the diameter of this part is not affected by any twisting motion of the neck.

The air-vessels are considerably larger than in the mammalia, and the substance of the lungs is not divided into lobuli. The cartilages of the trachea are lost before that tube enters the lung, and some of its large branches open on the surface of the viscus. In the ostrich this aperture is surrounded by circular muscular fibres, a peculiarity which does not seem to have been hitherto noticed

§ 179. Besides these cells, a considerable portion of the skeleton is formed into receptacles for air in most birds; for there are indeed exceptions and considerable variations in the different genera and species. This structure is particularly marked in the larger cylindrical bones, as the scapula, clavicle, and femur. It is also found in most of the broad and multangular bones of the trunk, as the sternum, ossa innominata, dorsal vertebræ, &c. All these are destitute of marrow[‡] in the adult bird, at least in their middle; so that the cylindrical bones form large tubes, which are only interrupted towards the extremities by a sort of transverse bony fibres; the broad bones are filled with a reticulated bony texture, the cells of which are empty. They have considerable apertures[§] (most easily shown in those extremities of the cylindrical bones

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the chest of the bird, can be properly compared to the diaphragm. See J. Hunter, in the *Philos. Trans.* vol. lxiv. part i. p. 207; and Mich. Girardi, in the *Memorie della Società Italiana,* tom. ii. part ii. p. 739.

[*] Wepfer, *Cicutæ Aquaticæ Historia,* p. 171.

[†] J. B. Du Hamel, *Historia Academ. Reg. Scient.* p. 141.

[‡] This fact was known to the Emperor Frederic II. See his treatise *De Arte venandi cum Avibus,* p. 39 of Schneider's edition.

[§] Camper's *Kleine Schriften,* vol. i. part i. tab. 1 and 4.

which are turned towards the sternum) communicating with the lungs by small air-cells; which facts may be shewn by various experiments on living and dead birds.*

These receptacles of air probably serve the purpose of lightening the body of the bird in order to facilitate its motions. This effect is produced in most birds to assist their flight;† in some aquatic species, for the purpose of swimming; in the ostrich and some others for running. Hence we find the largest and most numerous bony cells in birds which have the highest and most rapid flight, as the *eagle*, &c. And hence also the bones of the bird which has just left the egg, are filled with a bloody marrow, which is absorbed soon after birth, entirely in some, in others, particularly among the aquatic species, for the greater part.

We may however conclude on the other hand, that all these bony receptacles of air are not, like those of the thorax and abdomen, immediately connected with the respiration of the animals. For in many birds the interval between the two tables of the cranium contains air, while the apertures for its admission are not connected with the lungs, but merely with the Eustachian tube.

§ 180. The immense bill of some birds, which are for that reason called *levirostres*, is provided with air from the same quarter. This structure is not therefore connected, as some anatomists‡ have supposed, with the organ of smelling, but forms a part of the air-cells.

§ 181. Besides the uses which have been already pointed out, these receptacles of air diminish the necessity of breathing frequently in the rapid and long continued motions of several birds, and in the great vocal exertions of the singing birds.* They are also obviously serviceable in the evacuation of the fæces, and probably assist in the expulsion of the egg.

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* Some curious experiments have been made on this subject by Dr. Albers. He made living birds respire the different gases through the air-cells of their bones by means of an apparatus invented for the purpose. See his *Beyträge zur Anatomie und Physiologie der Thiere,* part i. Bremen, 1802, 4, p. 110.

† Willis *De Anima Brutorum,* p. 30. Reimarus, in Reil's and Autenrieth's *Archiv.* vol. xi. p. 229.

‡ Cajet. Monti, in the *Comment. Instit. Bonon.* tom. iii. p. 298; and recently S. Traill, in the *Trans. of the Linnæan Society,* vol. xi. p. 11.

The bones of birds, in so far as their air-cells are concerned, form two distinct systems, the one being filled with air through the trachea and lungs, the other immediately from the mouth or nose. To the latter the bones of the head, to the former those of the trunk, of the neck and extremities belong. With very little practice one may tell, in a bone fully developed, whether it contains air-cells or not, from the mere external appearance, without at all seeing the opening through which the air enters. Such bones, in addition to their being devoid of marrow, are generally of a clearer white colour than those filled with marrow. Frequently the external walls of the air-bones are so thin that their internal cells can be very well seen. Nevertheless, mere external appearances may deceive, and in order to prevent this the openings leading to the air-cells should be sought for- These openings are in general, as their connexion with the lungs or air-tubes renders necessary, situated in concealed parts, and the extremities of bones. This circumstance, coupled with their smallness, makes their discovery so difficult, that in many cases not only the cleaning of the skeleton and the separation of the bones from all their connexions, but also the minutest examination of their surface, are necessary to discover their existence. In long bones the openings to the air-cells is generally situated close to either extremity. In bones which exist in pairs there is commonly only one, or where several exist they are so close together as to be nearly united. The direction in which the openings penetrate the bony parietes is not uniform. Sometimes it is oblique, so that a short oblique canal is formed; at others there is an oblique groove with a sieve-like base for the entrance of the air. The edges of the openings are even, smooth, and rounded, which gives them a peculiarly regular appearance. Their shape is either circular, oval, or elliptical. Their breadth bears some kind of proportion to the size of the bone, or at least to the extent of the internal cells, so that large birds, and large bones, have much larger openings than the small ones. There are, however, very remarkable exceptions. With respect to the internal air-cells great differences exist. There has been found in the internal periosteum which lines the air-cells, in the bones of the upper and lower extremities, a fine net-work of blood-vessels. It is known that the air-bones in young birds are filled with marrow, which becomes gradually absorbed to make room for the admission of air. This gradual expansion of the air-cells, and absorption of the marrow, can no where be observed so well as in young tame geese when killed at different periods of the autumn and winter. The limits to the air-cells may be clearly seen from without by the transparency of the bony parietes. From week to week the air-cells increase in size, till towards the close of the season the air-bones become transparent. In all these bones the marrow first disappears from the vicinity of the opening which admits the air, and continues longest at the points further removed from this opening. Towards the close of the summer and beginning of autumn, although in external appearance the young goose resembles the parent, no trace of air-cells can be discovered in its bones, the interior of the bones being then filled with marrow. About the fifth or sixth month the marrow begins to disappear. This circumstance, which applies also to other birds, shows with what caution one should form an opinion, from young birds only, on the size of the air-cells. In many kinds of birds the air-cells of some bones are never fully developed, although they have the openings in the bones which lead to the air-cells. The obvious use of this construction in the bones of birds, appears to be that of lessening the weight of the bone as compared with its size, without at the same time diminishing their necessary peripherical extent. Whether birds possess the power of voluntarily letting out the air so as to render them specifically lighter, or whether they contain lighter gases in them, has not been ascertained. *Vid. Nitzsch's Osteograf. Beitrage*, p. 3.

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* Willis *De Anima Brutorum*, p. 30.

" In the *eagle*, *hawk*, *stork*, *lark*, and other high flying birds, these cells are very large; and in many of those birds there are still larger cells, ascending under the integuments of the neck, and passing beneath the skin of the inside of the arm and back of the shoulder. In the stork we find these cells large enough to admit the finger to pass a considerable way down upon the inside and back of the wing. They are also large in the owl and other birds of prey." Macartney in Rees's *Cyclopedia*, art. Birds.

AMPHIBIA.

§ 182. The lungs of amphibia* are distinguished from those of warm-blooded animals, both by a great superiority in point of size, as well as by a greater looseness of texture; which circumstances are serviceable in swimming in many of these animals.

It is well known that the lungs of *turtles* and *frogs* do not collapse on opening the animals, like those of mammalia, but often remain expanded, at least partially, for some time. Malpighi, and lately Townson,* have explained this phenomenon by the action of the constrictor muscles of the glottis. Bremond thought this insufficient according to his experiments, and ascribed much effect to the peculiar vitality of the lungs.†

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* On the respiratory system of this class, see Meckel, in his *Archiv.* vol. iv. p. 60.

The amphibia are distinguished in all instances by the great size of their air-vesicles. In the *frogs*, *lizards*, and *serpents*, the lung consists of a cavity, the sides of which are cellular. The lower, or posterior part of the organ, either forms a mere membranous bag (the parietes of which are not cellular), or else the vesicles are larger at that part than elsewhere. In the serpents the lung has that elongated form, which characterizes all the viscera of these animals. A considerable portion of it is a simple membranous cavity; and this is supplied with arteries from the surrounding trunks. The *turtles* have a more complicated structure, or one which approaches more nearly to that of the warm-blooded classes. The lungs are uniform in their texture throughout, but the vesicles are very large. The cartilaginous annuli of the bronchi terminate before these vessels enter the lungs.

§ 183. There are numerous projecting processes in the lungs of the *chameleon* ‡ and *newt;* in the latter animal they terminate behind in an elongated bladder. The serpents, at least for the most part, have only a single lung, which forms an elongated vesicular bag. In a coluber of four feet and a half long, the lung measured one foot one inch; its anterior half resembled a muscular intestine in appearance, and had an elegantly reticulated internal surface, which resembled on a small scale the inner surface of the second stomach of the ruminating animals. The posterior part formed merely a simple and long cavity with thin sides.

§ 184. In the *tadpole*, and the young of such *lizards* as bring forth in water, there are two organs, which somewhat resemble the gills of a fish (*appendices fimbriatæ*, Swammerdam).§ It has been doubted whether the young of the true salamander are provided with these appendices; and Latreille, in his *Histoire Naturelle des Salamandres de France*, p. 19, and seq. has the following question, "*Les jeunes salamandres terrestres ont elles des branches? voila une question que je mets encore au rang des problemes.*" I answered this question in the affirmative forty-one years ago; having observed that the young of some pregnant salamanders, whom I kept in my room in glasses, and who brought forth under my inspection, had considerable branchial appendices.* These appendices are connected to the sides of the neck, and hang loose from the animal; they are not permanent, but are gradually withdrawn into the chest, (within a few days, in the reptiles of this country (Germany), where their remains may still be perceived for some time† near to the true lungs. That doubtful animal, the *siren lacertina* from Carolina, has, according to Hunter's dissection, two bladder-like lungs, besides the external branchiæ.‡

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* *De Amphibiis.* Goett. 1794, 4.

† See on the same subject Rudolphi's experiments, in his *Anatomisch-Physiologische Abhandlungen*, p. 119. G. R. Treviranus, *Biologie*, vol. iv. p. 141; and especially Const. de Weltzien *De pulmonum autenergia in organico respirationis mechanismo.* Dorp. 1819, 102.

‡ Vallisnieri's *Istoria del Cameleonte*, p. 68, tab. 3.

§ *Biblia Naturæ*, p. 322. Rösel, tab. 2, fig. 18; and especially Conr. de

The same circumstance holds good respecting that no less mysterious creature, the *proteus anguinus*, from the Cirknitz or Sitticher lake of Carniola; whose remarkable internal structure has been described and delineated by Dr. Schreibers in the *Philos. Trans.* for 1801;§ and more recently by Signors Configliachi and Rusconi in their elaborate monograph on the *proteus anguinus*.

Instead of the branchial opening by which fishes again discharge the water, which they have taken in at the mouth,

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Hasselt *Observationes de Metamorphosi quarundam partium Ranæ temporariæ*. Groning. 1820; and M. Rusconi *Degli organi della circolazione delle larve delle Salamandre aquatiche*. Paris, 1817.

* See the *Specimen Physiologiæ comparatæ*, in the 8th vol. of the *Göttingen Commentaries*.

† Swammerdam, *loo. citat.* Rösel, p. 82, tab. 19, fig. 2.

‡ *Philos. Trans.* vol. lxv. p. 307.

§ On these two mysterious animals, as well as the larvæ of several *frogs* and *salamanders*, consult Cuvier's *Recherches Anatomiques sur les Reptiles regardés encore comme douteux par les Naturalistes*. Par. 1807; Humboldt's Travels, and Bonpland's 2nd part of his *Observations d'Anatomie comparée*, 1er vol. 1811. Configliachi et Rusconi *Monografia del Proteo anguino*. Pav. 1819.

some tadpoles have for this purpose a canal on the left side of the head near the eye,* which must be distinguished from the small tube on the lower lip, by which they attach themselves to aquatic plants.†

After an elaborate anatomical description of the *proteus anguinus*, Signors Configliachi and Rusconi proceed to inquire whether it be true, as many naturalists have believed, that this reptile breathes with its branchiæ and lungs at the same time, and, secondly, whether the *sirena lacertina* is to be considered by zoologists as a *larva*, or as a perfect animal. In respect to the bony apparatus of the branchiæ, they found a remarkable difference between the *proteus*, the *sirena*, and the larvæ of *salamanders* and *frogs*, both as to form and hardness. In the *siren* and *larvæ* there are four branchial arches on each side, which are furnished with several projections on the surface; in the *proteus* there are but three arches, which are perfectly smooth; those of the *proteus* are osseous, while those of the *siren* and *larvæ* are cartilaginous. These differences did not escape M. Cuvier, who in speaking of the *proteus*, observes, that the bony apparatus of the branchiæ is much harder than it is in the *sirena* and the *axolotl*. Signors Configliachi and Rusconi observed in the *larvæ* of *frogs*, that when their spine is nearly hardened into bone, and their metamorphosis is beginning to be accomplished, the branchial arches become softened, and ready to be absorbed. They observed the same thing in the larvæ of *salamanders*, with this difference, that the ossification of the spine takes place in the latter much sooner than the period of their metamorphosis; and when that period arrives, the portion of their branchial apparatus, which remains to be converted into the os hyoides, instead of softening, becomes hardened into bone. Thus their observations fully confirm the conjecture of M. Cuvier, who, in his description of the *axolotl*, has observed, that the apparatus supporting the branchiæ has a great resemblance to that of the *sirena*, and that probably, at the period of its metamorphosis, a portion remains to form the os hyoides of the *salamander*. Now, if the branchial arches of the *sirena*, dissected by M. Cuvier, were entirely cartilaginous, although the cranium, the lower jaw, and the vertebræ, were already perfectly ossified, and if these are similar, in form and number to those of the *axolotl*, which, in the opinion of M. Cuvier himself, is a *larva*, and if, moreover, the branchial arches of the *proteus*, which is a perfect animal, are osseous, and different in all respects from those of the larvæ hitherto known, do not all these facts furnish us with a strong argument to prove that the *sirena*

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* Rösel, tab. 8, fig. 7, 8. This organ is very conspicuous in the large larvæ of the *rana paradoxa*.

† Rösel, tab. 14, fig. 17. Rosenthal, in the *Verhandl. der Berlin naturforsch. Gesellsch*, vol. i. part 1, 1819.

lacertina is a perfect animal, and therefore essentially different from the *proteus?* Signors Configliachi and Rusconi, after a minute examination of the organs of circulation and respiration in the *proteus, sirena*, and above mentioned *larvæ*, conclude, that the *proteus anguinus* is not an amphibious animal, with a double circulation, as many have asserted, but a perfect reptile, entirely differing from all others, inasmuch as it is a reptile in respect of its simple circulation, and a fish in respect of its mode of breathing; in other words, it is a reptile which in breathing inhales air mixed with water, whereas other reptiles breathe atmospheric air; so that if we adopt the notion of a chain of beings, the *proteus anguinus* would be the link uniting reptiles with fishes. As the *proteus* is an animal which breathes only in the water, and as its branchial circulation can be regarded only as a minute part of its general circulation, it follows that it consumes less oxygen than fishes. Hence the quantity of blood which is decarbonized in its branchiæ, within a given space of time, must be much less than that which, under similar circumstances, is decarbonized by fishes. This accounts for its inertness, its slow growth, its power of fasting longer than any other animal of its class, the fluidity of its blood, and its capability of living in stagnant water, where a fish of its size would die.

FISHES.

§ 185. Instead of *lungs*, this class of animals is furnished with *gills* or *branchiæ;* which are placed behind the head, on both sides, and have a moveable gill-cover, (*operculum branchiale*) which is wanting in the order of *pisces chondropterygii* only. By means of these organs, which are connected with the throat, the animal receives its oxygen from the air contained in the water;* as those animals which breathe, derive it immediately from the atmosphere. They afterwards discharge the water through the branchial openings (*aperturæ branchiales*); and therefore they are distinguished from animals of the three preceding classes by this circumstance; viz. that they do not respire by the same way that they inspire.

§ 186. We have already shewn how the gills receive the venous blood by means of the branchial artery, and how this blood is sent into the aorta after its conversion into the arterial state. The distribution of these vessels on the folds and divisions of the gills constitutes one of the most delicate and minute pieces of structure in the animal economy.*

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* Vide Dumeril, on the mechanism of respiration in fishes, in the *Magazin. Encyclopedique*, by Millin, 1807, vol. vi. p. 35.

Each of the gills consists, in most fishes,† of four divisions, resting on the same number of arched portions of bone or cartilage, connected to the os hyoides. Generally there is only a single opening for the discharge of the water; but in many cases, particularly among the cartilaginous fishes, there are several openings.

§ 187. Many animals of this order possess a single or double swimming bladder,‡ which in the fresh-water fishes of this country, (Germany) contains azotic gas; and in salt-water fishes, chiefly carbonic acid gas. It has not been hitherto determined, whether it be subservient to any other functions,§ besides that well known one, from which its name is derived. In the mean time, like the air-receptacles of birds it may be considered without impropriety in the present division of the work.

It is placed in the abdomen, and closely attached to the spine. It communicates generally with the œsophagus, and sometimes with the stomach, by a canal (*ductus pneumaticus*) containing, in some instances, as the *carp*, valves which seem to allow the passage of air from the bladder, but not to admit its entrance from without.

The air-bladder does not exist in many fishes; whence Cuvier argues with justice against the opinion which assigns this part an important office in respiration. Indeed it seems much more probable that it is subservient to the motions of the animal. For it is largest in such fishes as swim with considerable velocity. It is wanting in the flat fishes; where the large lateral fins supply its place, and in the *shark*, where its absence is compensated by the size and strength of the tail. It does not exist in the *lamprey*, which possesses none of these compensations for its absence; that fish therefore creeps slowly at the bottom of the water.

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* Fischer's *Naturhistor. Fragmente,* vol. i. p. 213.

† It is represented by Monro, in the *haddock* and *salmon,* tab. 25 and 26.

‡ See Gott. Fischer *über die Schwimmblase der Fische.* Leipzig, 1795, 8vo.; and additions to it in his *Naturhistor. Fragmente,* vol. i. p. 229, &c. In both these works he delineates the bladders of several fishes. Representations of several others may be seen in Needham *De Formato Fœtu,* tab. 7. Redi, *De Viventibus intra Viventia,* tab. 3, 6; and the *Obs. Anat. Collegii privati Amstelod.* pt. 2, tab. 10.

§ Consult Aug. W. Zachariä's *Elemente der Luftschwimmkunst.* Wittenb. 1807, p. 90.

On the remarkable connexion with the organ of hearing, vide E. H. Weber *De aure Animalium aquatilium.* Lips. 1820, 4.

It is found in some species of *scomber:* while others want it, viz. the *mackarel* (*scomber scombrus*). Its form is infinitely varied in the different genera and species. Its cavity is generally uniform; but sometimes divided by septa, as in the *silurus;* and being even very cellular in the *diodon.*

Its sides vary considerably in thickness, and are sometimes bony, as in the *cobitis fossilis.*

There is generally a vascular and glandular body situated in the cavity, which probably secretes the contained air. In the *perca labrax* are two bodies on the outside of the bag, giving rise to several vessels, which contain air. These unite together, and open into the cavity.

INSECTS.

§ 188. That white-blooded animals indispensably require a species of respiration, would have been inferred by analogy from the wonderful apparatus of gills or tracheæ, which have been discovered in most orders of both classes of these beings. But in many cases direct proof has been obtained on this point: experiment has actually proved the exchange of carbon for oxygen.*

White-blooded animals are moreover distinguished from those which have red blood, by this circumstance, that none of the former, as far as we hitherto know, take in air through the mouth.

§ 189. Many aquatic insects,† as the genus *cancer*, have a species of gills‡ near the attachment of their legs. The others, and particularly the land-insects, which constitute, as is well known, by far the greatest number of this class of animals, are furnished with air-vessels or tracheæ, which ramify over most of their body.* These tracheæ are much larger and more numerous in the larva state of such insects as undergo a metamorphosis (in which state also the process of nutrition is carried on to the greatest extent) than after the last, or, as it is called, the perfect change has taken place.

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* See the two following very valuable works, F. L. A. Sorg, *Disquisitio Physiologica circa Respirationem Insectorum et Vermium;* and Fr. Hausmann, *Tentamen solutionis a Societat. Reg. Scientiar. Gotting. circa Respirationem Insectorum propositæ Questionis.*

† I. F. Martinet *De Respiratione Insectorum.* Lugd. Batav. 1753-4.

‡ They are represented in the *crawfish* by Willis, *De Anima Brutorum.* tab. 3, fig. 2 and 3; and in Rösel's *Insectenbelustigungen*, part iii. tab. 58, fig. 9, 11, tab. 59, fig. 17; and in G. Succow, *Specimen Myologiæ Insectorum*, tab. 1, fig. 1.

In this class of animals the *scorpions*, being also provided with fins, present an extraordinary instance of an animal, which, though living nearly in the air, breathes like fishes.†

§ 190. A large air-tube (*trachea*) lies under the skin on each side of the body of larvæ, and opens externally by nine apertures (*stigmata*): it produces on the inside the same number of trunks of air-vessels, (*branchiæ*) which are distributed over the body in innumerable ramifications.‡

Both the tracheæ and branchiæ are of a shining silvery colour; and their principal membrane consists of spiral fibres. The most numerous and minute ramifications are distributed on the alimentary canal; particularly on the above-mentioned corpus adiposum.

§ 191. There is a great variety in the number and situation of the external openings by which insects receive their air.§

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* Cart. Spreyel *De partibus quibus insecta spiritum ducunt.* Leips. 1815.

† Treviranus *über den innern Bau der Arachniden.* Nurnb. 1812.

‡ Lyonet *Anatomie de la Chenille*, &c. tab. 4, 5, 6, 7, 10, and 11. The same organs have been represented by Swammerdam, in the *scarabæus nasicornis*, tab. 29, fig. 9, 10, tab. 30, fig. 1, 10. In the *lucanus cervus* (stag-beetle) by Malpighi, *De Bombyce*, tab. 3, fig. 2; in a *cicada*, ibid. fig. 3. In a *gryllus*, (grasshopper) ibid. tab. 4, fig. 1; also by Cuvier, in the *Mém. de la Soc. d'Hist. Naturelle de Paris*, an 7, p. 39. In the silk-worm by Malpighi, tab. 3, fig. 1. In a *libellula* by Cuvier, in the work just quoted, fig. 2, 5, 6. In the *Ephemera* by Swammerdam, tab. 14, fig. 1, tab. 15, fig. 1, 4, 7. In the *bee*, ibid, tab. 17, fig. 9, 10, tab. 25, fig. 10, tab. 24, fig. 1, 2, 3. In the *œstrus bovis*, by Mr. B. Clark, in the *Transact. of the Linnæan Society*, vol. iii. tab. 23, fig. 25. In the *maggot of the fly* by Swammerdam, tab. 40, 41, 42, 43. In the *louse*, ibid, tab. 1, fig. 8, 4, 7.

§ See the work above quoted, by Haussmann.

In most instances the stigmata are placed on both sides of the body. The atmospheric air enters by an opening at the end of the abdomen in several aquatic larvæ, and even perfect insects. A very remarkable change in this respect takes place in several animals of this class during their metamorphosis. Thus in the larva of the common *gnat*, (*culex pipiens*) the air enters by an opening on the abdomen; while in the nympha of the same animal, it gains admission by two apertures on the head.*

VERMES.

§ 192. In this class, which comprehends such very different animals, the structure of the respiratory organs is proportionally various.† Some orders, as those which inhabit corals, the proper *zoophytes*, and perhaps the *intestinal worms*, appear to be entirely destitute of these organs; so that if any vital function, analogous to respiration, is carried on in these animals, it must be effected by methods which yet remain to be discovered.

§ 193. Those vermes, however, which are furnished with proper organs of respiration, have the same variety in their structure which was remarked in insects. Some, as the *cuttle-fish*,‡ *oyster*,§ &c. have a species of gills, varying in structure in different instances. But the greatest number have air-vessels or tracheæ.|| Several of the testaceous vermes have both

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* Swammerdam, *Algem. verhandel. Van de Bloedeloose Dierkens*, tab. 2.

† The reader may consult on this subject Cuvier, in the *Journal d'Histoire Naturelle*, 1792, tom. ii. p. 85; and in his *Tableau d'Histoire Naturelle des Animaux*, p. 384; also Sorg and Haussmann, in their works quoted above. And Spallanzani *Mémoires sur la Respiration*. Genève, 8vo. 1803.

‡ Swammerdam, *Biblia Naturæ*, tab. 51, fig. 1. Monro, tab. 41, fig. 1. And particularly Dr. C. F. G. Tilesius *De Respiratione Sepiæ Officinalis*. Lips. 1801-4, tab. 1, 2.

§ Willis, tab. 2.

|| Examples of this structure in testaceous vermes may be seen in the *lepas balanus*, (acorn-shell) Poli, tab. 4, fig. 20, 22. In the *pholas dactylus*, (pierce-stone) ibid. tab. 8, fig. 61. In the *solen strigilatus*, (razor-shell) tab. 13, fig. 5. In the *helix pomatia*, (snail) Swammerdam, tab. 4, fig. 1.

kinds of respiratory organs. In some of the inhabitants of bivalve shells, as the genus *Venus*,* the air-vessels lie between the membranes of a simple or double tubular canal, found at the anterior part of the animal, and capable of voluntary extension and retraction. It serves also for other purposes, as laying the eggs. The margins of its mouth are beset with the openings of the tracheæ.

In the terrestrial *gasteropodous mollusca*, of which we may instance the *snail* and *slug*, there is a cavity in the neck receiving air by a small aperture, which can be opened or shut at the will of the animal. The pulmonary vessels ramify on the sides of the cavity.

The *common slug* affords an instance in the mollusca, see Swammerdam, tab. 8, fig. 7, tab. 9, fig. 1, and the *leech* in the intestinal worms, Bening *De Hirudinibus*, p. 20; and P. Thomas, *Histoire Naturelle des Sangsues*. Par. 1806.

* In the *Venus lata*, Poli, tab. 2, fig. 17.

CHAPTER XV.

ON THE ORGAN OF THE VOICE.

§ 194. Aristotle has correctly observed, that those animals only, which possess lungs, consequently the three first classes of the animal kingdom, possess a true voice. Several genera and species even of these are either entirely dumb, as the *ant-eater*, the *manis*, the *cetacea*, the genus *testudo*, several *lizards* and *serpents;* or they lose their voice in certain parts of the earth; as the *dog* in some countries of America, and *quails** and *frogs*† in several parts of Siberia.

In a preparation—a dried one indeed—of the larynx and lungs of the two-toed ant-eater, I find the larynx entirely bony, that is, of the same substance with the os hyoides. The trachea, which is extremely short, is a merely membranous canal, without any perceptible trace of cartilaginous rings. J. Hunter found no thyroid gland in the *whales*, which he dissected. This coincides with the hypothesis upon which this gland is supposed to be connected with the formation of the voice.

MAMMALIA.

§ 195. Most animals of this class‡ have the following circumstances in common; their rima glottidis is provided with an epiglottis, which in most instances has a peculiar muscle, arising from the os hyoides, and not found in the human subject: the margins of this rima are formed by the double ligamenta glottidis (*ligamenta thyreo-arytænoidea*); between which on each side the ventriculi laryngis are situated. The epiglottis does not exist in most of the *bat* kind; and in some mouse-like animals, as the *rell-mouse*, (*glis esculentus*) it is hardly discernible. The superior ligamenta glottidis, as well as the ventriculi laryngis are wanting in some *bisulca*, as the *ox* and *sheep*.

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* Pennant's *Arctic Zoology*, tom. ii. p. 320.

† Muller's *Sammlung Russischer Geschichte*, vol. vii. p. 123. J. C. Beckmann's *Historische Beschreibung der Chur und Mark-Brandenburg*, vol. i. p. 590.

‡ Besides the two old and highly valuable works on the organ of the voice, by Casserius and Fab. Ab Aquapendente, and the writings which we shall have occasion to quote in the sequel, I refer the reader to M. J. Busch, *Dissert. de Mechanismo Organi Vocis.* Groning. 1770, 4to. which contains several excellent observations by

§ 196. Some species of mammalia have a peculiar and characteristic voice; or at least certain tones, which are formed by additional organs. Thus there are certain tense membranes in some animals; and in others peculiar cavities, opening into the larynx, and sometimes appearing as continuations of the ventriculi laryngis, which are destined to this purpose.

The neighing of the *horse*, for example, is effected by a delicate, and nearly falciform membrane, which is attached by its middle to the thyroid cartilage, and has its extremities running along the external margins of the rima glottidis.*

The peculiar sound uttered by the ass is produced by means of a similar membrane; under which there is an excavation in the thyroid cartilage. There are moreover two large membranous sacs opening into the larynx.†

The *mule* does not neigh like the mare, by which it was conceived; but brays like the *ass* which begot it. It possesses exactly the same larynx as the latter, without any of the peculiar vocal organs of the mother: a fact which, like many others,

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Camper. See also L. Wolf, *Diss. Anatomica de Organo Vocis Mammalium.* Berol, 1812. On the peculiar structure of this organ in *cetacea*, see Camper *Sur la Structure Intérieure de plusieurs cétacés.* Albers's *Icones*, fasc. 2; and Rudolphi, in the *Abhandlung der Berlin. Akad physik.* 1820.

* Herissant in the *Mém. de l'Acad. des Sc.* 1753, tab. 9.

† Ibid. tab. 10.

cannot be at all reconciled with the supposed pre-existence of previously formed germs in the ovarium of the mother.

I have adduced this essential, and really specific difference in the structure of the larynx of the horse and ass: as one of the many arguments which overthrow the rule adopted by Ray, Buffon, and others, of ascribing to one and the same species all such animals as produce by copulation an offspring capable of subsequent generation.*

The *cat* has two delicate membranes lying under the ligamenta glottidis; which probably cause the purring noise peculiar to these animals.†

The *pig* has two considerable membranous bags above and in front of the ligamenta glottidis.‡

Several *apes*§ and *baboons*,|| as also the *reindeer*, have on the front of the neck large single or double laryngeal sacs, of various forms and divisions, communicating with the larynx by one or two openings between the os hyoides and thyroid cartilage.

In a common *ape* (*simia sylvanus*) I found the right laryngeal sac three inches long, and two inches in circumference; while the left was not larger than a nutmeg. The larynx of the *simia cynomolgus* may be seen in Camper's account of that animal.¶

Some of the *cercopitheci*, as the *cercopithecus seniculus*, and *Beelzebub*, have the middle and anterior part of the os hyoides formed into a spherical bony cavity,** by which the ani-

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* See Gore's *Translation of Blumenbach's Manual History*, p. 8.

† Vicq d'Azyr, in the *Mém. de l'Acad. des Sciences*, 1779, tab. 11, fig. 17.

‡ Casserius *De Vocis Auditusque Organis*, tab. 11, fig. 9, 10, p. 55, *ad grunnitum in porcis efficiendum.* Herissant, *loco citato*, tab. 11.

§ As the orang-outang. See Camper's Natural History of that animal—the *simia inuus*, see Ludwig's *Grundriss der Naturgeschichte der Menschenspecies.*

|| It is represented in the mandrill, (*papio maimon*) by Vicq d'Azyr, *loco citato*, tab. 7.

¶ Camper, *loco citato*, tab. 8, fig. 7.

** Vicq d'Azyr, *loc. cit.* tab. 9, 10. Camper, tab. 4.

mals are enabled to produce those terrific and penetrating tones, which can be heard at vast distances, and have gained them the name of the howling apes.

The larynx of mammalia is generally of the same conformation as in man. None of the large cartilages of the larynx are deficient, and the opinion that some animals of this class want the epiglottis is quite erroneous. In several, as the *bat* for instance, it is extremely small. The size of the larynx is proportionate to the strength of the sounds which the animals utter. The absolute size of the larynx of the *whale* and the *elephant* is the largest, but relatively the larynx of the *lion* has a still greater circumference. The cartilages vary in their form; in the *cercopitheci seniculi* the os hyoides is dilated to a large bony pouch, and the thyroid cartilage at the same time bent forwards, which explains the deafening noise which they emit. In some animals, as the *antelope gutturosa,* there is a dilatation of the thyroid cartilage, and in some there are fleshy appendices, or air-sacs, which have their exit from the ventricles of Morgagni, or below the epiglottis, and therefore are sometimes single and at other times double. The *apes* of the old world have these sacs, and the *orang-outang* has them doubled; in others, as the *green ape,* they are single; this is also the case in the *reindeer.* In reality the depressions of the ventricles in the *pig,* or above the thyroid cartilage, as in the *horse* and *kangaroo,* may be regarded as the incipient state of this structure.

In most mammalia the number and situation of the vocal ligaments are the same as in man. The trachea in long-necked animals, is naturally much lengthened, and the number of rings increased; in men there are from seventeen to twenty in number, whereas in the *camel* there are seventy-four; in the *stag,* fifty-three; in the *bullock,* fifty-two; in the *domestic mouse,* there are from fourteen to fifteen; in the *hedgehog,* eighteen; in the *rat,* twenty-one; in the *beaver,* twenty-two; in the *cercopithecus seniculus,* twenty-four; in the *bear,* twenty-eight; in the *hyæna,* thirty-six; in the *lion, cat, dog,* and *rabbit,* thirty-eight; in the *hog,* from thirty-eight to forty; in the *lynx* and *guinea-pig,* forty; in the *hare,* forty-four; in the *wolf, otter,* and *sheep,* fifty; in the *roe,* sixty-three; in the *ferret,* sixty-seven; in the *seal,* seventy-eight. In many animals, as in the *cercopithecus seniculus, lion,* and *bear,* the space between the end of the rings is very great, so that the trachea can be very considerably narrowed, which structure contributes to the intensity of the sounds they are capable of emitting. In the *hyæna* the extremities of the rings of the trachea lap over each other, and are also capable of being much compressed; a structure which probably occasions the peculiar cry of that animal. In a few mammalia the tracheal rings are closed: entirely so in the *beaver,* and in the upper part of the trachea in the *seal.* The muscles and nerves of the larynx present in mammalia little variation from those of the human subject, except that in many animals those of the epiglottis are fully developed, whereas in man they are very indistinct. See Rudolphi's *Grundriss der Physiologie*, vol. ii. part 1, p. 380; to which excellent work we are indebted for much of the additional matter inserted in this edition.

BIRDS.

§ 197. The most striking peculiarity in the vocal organs of this class, a peculiarity which belongs to all birds with a very few exceptions, consists in their possessing, what is commonly called, a *double larynx*, but which might be more properly described as a larynx divided into two parts, placed at the upper and lower ends of the trachea. They have also two rimæ glottidis.

§ 198. The superior or proper rima glottidis is placed at the upper end of the trachea, but is not furnished with an epiglottis.* The apparent want of this organ is compensated in several cases by the conical papillæ placed at both sides of the rima.

§ 199. The apparatus, which is chiefly concerned in forming the voice of birds, is found in the inferior or bronchial larynx. Hence the division of the trachea below the upper rima glottidis scarcely produces any change in the voice of several birds, as they can still utter sounds by means of the bronchial larynx.† This larynx contains a second rima glottidis, formed by tense membranes; which may be compared in several cases, particularly among the aquatic birds, to the reed pipes of an organ. It is furnished externally with certain pairs of muscles, varying in number in the different orders and genera; and with a kind of thyroid gland. The course and proportionate length of the trachea, and particularly the structure of the inferior larynx, vary very considerably* in the different species, and even in the two sexes, especially among the aquatic birds. Thus, for example, the tame or dumb swan (*anas olor*) has a straight trachea, whilst in the male of the wild or whistling swan, (*cygnus*) this tube makes a large convolution, which is contained in the hollow of the sternum (see § 56). In the spoonbill (*platalea leucorodia*) as also in the *phasianus motmot*, and others, similar windings of the trachea are found, not inclosed in the sternum. In many *swimming birds* the males have at their inferior or bronchial larynx a bony cavity, the form of which varies in different species,† and which contributes to strengthen their voice.‡

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* The part which Warren has described in the 34th vol. of the *Philos. Trans.* p. 113, as the epiglottis of the ostrich, is merely a slight elevation at the root of the tongue. See Cuvier, in the *Ménagerie du Museum National d'Histoire Naturelle*, No. 1, tab. 3.

† See Duverney, in the *Hist. de l'Acad. des Sciences*, tom. ii. p. 7. Girardi, in the *Memorie della Società Italiana*, tom. ii. pt. ii. p. 737; and Cuvier, in the *Magazin Encyclopédique*. Arm. i. tom. ii. p. 357.

" A very little comparison of the mechanism of wind musical instruments with the organs of the voice in birds will shew how nearly they are allied to each other; and it may be observed, that the sound produced by some of the larger birds is exactly similar to the notes that proceed from a clarionet or hautboy in the hands of an untutored musician. The inferior glottis exactly corresponds to the reed, and produces the tone, or simple sound. The superior larynx gives it utterance, as the holes of the instrument; but the strength and body of the note depend upon the extent and capacity of the trachea, and the hardness and elasticity of its parts. The convolution and bony cells of the windpipe, therefore, may be compared with the turns of a French horn and the divisions of a bassoon; and they produce the proper effects of these parts in the voices of those birds in which they are found." Rees's *Cyclopædia*, art. Birds.

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* On the subject of the bronchial larynx, the reader may consult Herissant, Vicq d'Azyr, and Cuvier, in their works already quoted: also another dissertation by the latter author in the 2nd vol. of the fourth year of the *Magazin Encyclopédique*. Schneider, in the *Leipsig Magazine* for 1786 and 1787, and in his valuable *Commentary on the Works of Frederic II.* pp. 32, 211.

Aldrovandi has described that of the *wild swan*. *Ornitholog.* tom. iii. p. 13.

That of the *goose* has been most excellently described by Haller *De partium corp. humani fabrica et functionibus*, tom. vii. p. 321, which may be compared with the beautiful delineations of Herissant, *loc. citat.* tab. 12.

† Besides Herissant and Cuvier, *loc. citat.* the reader may consult Aldrovandi, *Ornithol.* tom. iii. p. 190. Willoughby, *Ornithol.* tab. 73. Bloch, in the *Beschäfte der Berliner Naturf. Gesellsch.* Berlin, tom. iv. p. 579, tab. 16; and in his works, tom. iii. p. 372, tab. 7. Latham, in the *Transactions of the Linnæan Society*, vol. iv. p. 90, tab. 9, 16.

‡ See Fabricius Hildanus, *Beschreibung der Fürtrefflichkeit der Anatomie*, p. 323.

The larynx of birds is divided into an upper and lower, and the lower forms the proper organ of voice. At the point where the lowest bony ring of the trachea branches off to form the bronchia, the skin folds on itself, and constitutes at the opening of each bronchus an elastic membrane, which projects into it, somewhat analogous to the vocal ligaments in mammalia. In the *parrot* tribe this division does not exist, and consequently there is not a double rima glottidis, as in other birds provided with vocal organs. Cuvier could not find this membrane in the *vultur papa*; and Rudolphi, who had an opportunity of examining this *vulture*, as well as the *vultur aura*, was unable to discover it. Singing birds have five pairs of muscles, and the parrots three, which are attached to the semi-circular rings of the divisions of the trachea, and relax or tighten the rimæ glottidis. Birds which utter a single cry, as the *accipitres* and many *aquatic birds*, have only one such pair of muscles; other *aquatic birds* and the *gallinæ* have none. Cuvier has admirably proved in living birds that this lower larynx is the proper organ of voice; he divided the trachea above the lower larynx, and closed the upper part of it. The irritated animal emitted by the lower larynx its accustomed sounds in a weaker tone; the same sounds were emitted when he removed the whole neck. The parts analogous to the cartilages of the larynx in man are very small in birds, and in structure bear a greater resemblance to bone. In most birds they lie close behind the tongue and the os hyoides, and form the commencement of the trachea. The fissure which they form, and which is not protected by an epiglottis, is opened by one pair of muscles, and closed by another. It merely serves for the passage of the air, being the commencement of the organ of respiration.

The trachea presents in many birds very remarkable differences. In some gallinaceous birds it makes a great curve before the sternum, as in the *crax* and *penelope*. In the *urogallus* (cock of the wood) this curve takes place in the neck; in the *crane* and *anas cygnus* in the keel of the sternum. In many *aquatic birds* as the *anas clangula, fusca*, &c. the trachea is considerably dilated in one or more places.

In general the great development of the vocal organs is peculiar to the male; as, for instance, the curve external to the sternum, the osseous bladders of the trachea, and of the lower larynx; the greater curvatures in the keel of the sternum occur in both sexes; in males, however, they are stronger.

AMPHIBIA.

§ 200. The structure of the vocal organs in this last class of animals, which possess a voice, is on the whole very simple; although it varies in several genera and species, and sometimes in the two sexes.

§ 201. The tortoises (at least the *testudo græca*) may be said to have two tracheæ: for the short common trunk divides at the third cervical vertebra into two long branches, which descend far into the chest before they enter the lung. Each of them makes a large lateral curvature, over which the two *aortæ abdominales* bend their course.* It is very short in the frog; but longer in the male than in the female: the rima glottidis is also larger in the former. Ligamenta glottidis exist in all the animals of this class.†

§ 202. The males of some frogs are distinguished by peculiar air-bags. The tree-frog (*rana arborea*) has a large sac in its throat; and the green frog (*rana esculenta*) has two considerable pouches in the cheeks, which it inflates at the time of copulation by two openings close to the rima glottidis.‡

All *amphibia* have the opening of the larynx without an epiglottis, and the cartilages which form the larynx are very analogous to those of the upper larynx of birds. *Frogs,* and some of the *lizards,* possess a structure similar to the vocal ligaments. In the *rana pipa* Rudolphi found a very curious structure: in the male the larynx was composed of two laminæ of bone, compressed from above downwards, of about ten lines in length, seven and a half lines broad at the base, and six and a half in the centre. In the female it was smaller, and merely cartilaginous. The bronchi proceed from the larynx directly backwards, being very short in the male, and long in the female. In the *gecko fimbriatus* Tiedemann (Meckel's *Archiv.* iv. s. 549) discovered in the trachea immediately below the larynx a dilatation half an inch long, and three lines broad, which he supposes to be of service to the animal when under water; for it has been asserted that this *gecko* lives several months in the year in fresh water at Madagascar, though Rudolphi thinks this very improbable, since its structure has not the remotest resemblance to that of an aquatic animal. This learned naturalist considers it, from analogy to birds, of use in strengthening the organs of voice, as in the *pipa;* and this opinion is confirmed by the circumstance of another *gecko* (the toc-kai of Siam) being distinguished for its discordant cry.

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* Blazii, *Zootomia.* Amst. 1677, 8vo. tab. 17, fig. 5.

† Vicq d'Azyr, *loc. citat.* tab. 13, fig. 45, 46, represents these fragments in the testudines, fig. 41, 42, 44, in frogs, fig. 47, 52, in serpents.

The larynx of the rattlesnake is represented in Tyson's *Anatomy of a Rattlesnake, Philos. Trans.* vol. xiii. No. 144, fig. 5.

‡ See Camper's *Kleine Schriften,* vol. i. part i. p. 144, tab. 3, fig. 1, 4.

A very shrill sound is uttered by *frogs*, especially the *bull-frog* (*rana ocellata*). Whether the singing-bladders, as they are termed, of the *green frogs* of Germany, assist them in uttering this sound, as P. Camper thinks, (*Kleine Schriften*, vol. i. s. 141, 150) is still a matter of great doubt; since these structures do not communicate with the larynx, but only with the mouth. According to Humboldt, (*Obs. zur Zoologie*, vol. i. p. 11) young *crocodiles* utter a sound similar to that of cats; but he never heard any cry proceed from the old ones. Most *lizards*, all the *testudines*, and *tailed tadpoles* are dumb. This is also the case with serpents, since their hissing cannot be called a true voice. (Rudolphi *Grundriss der Physiologie*, vol. ii. p. 387.)

One exception to the last observation of Rudolphi will suggest itself to the reader; but it may be doubted whether, even before the Fall, serpents were endowed with the gift of speech. Dr. Burnet, in his *Archæologiæ Philosophicæ*, rejects the Mosaic account of the dialogue between Eve and the serpent, not indeed as fabulous, but as fictitious or parabolical; and the silence of the physiologist is excused, therefore, by the scepticism of the divine. *Bestiam illam loqui posse*, says Dr. Burnet, *aut quacumque voce præter sibila nondum scimus. At quid de ea re scivisse Evam credemus? Si pro muto animali habuisset, ipsa loquela terruisset fœminam, et ab omni sermonis commercio pepulisset. Quod si loquax fuit, et sermocinator ab initio serpens, perdiditque loquelam ob hoc facinus quod pietatem fidemque Evæ suis blanditiis corruperat, hoc genus pœnæ neutiquam tacuisset Moses; neque levius damnum de lambendo pulvere ipsius loco substituisset. Præterea vis unicum serpentum genus, vel omnes bestias agri vocales fuisse in Paradiso; ut olim arbores in nemore Dodonæo? Si omnes, quid commisere cæteræ ut usum linguæ perderent? Si unicum serpentum genus hoc gaudebat privilegio; fœdum animal et ab humana specie alienissimum qui potuit mereri præ aliis omnibus, sermonis gratiam et beneficium?* "We know not whether the serpent had naturally the faculty of talking, or of producing any sound, beyond the hissing noise which is all it can achieve in these days. What shall we suppose Eve to have known about this matter? If she considered it a dumb animal, the very circumstance of its entering into conversation with her must have alarmed a timid female, and deterred her from continuing so monstrous an intercourse. But if the serpent talked at its creation, and lost the gift of speech for its wickedness in corrupting Eve, Moses would not have failed to mention this punishment, nor would he have substituted in its place the lighter inconvenience of being condemned to lick the dust. Again, will it be contended that the race of serpents alone, or that all beasts had the gift of speech in Paradise, like the talking trees in the grove of Dodona? If they all talked, what have the rest done that they too should lose the gift of speech? If serpents alone enjoyed this privilege, how shall we account for this distinction having been specially conferred upon an animal of such a nasty description, and so utterly unlike the human species?"

Dr. Burnet, while he admits with philosophical candour that the whole of the Mosaic account of the creation might be regarded as fabulous, if found in a profane writer, and while he exposes the absurdities involved in a literal interpretation of the Jewish cosmogony with an air of pleasantry which might be mistaken for ridicule in a less pious inquirer, acknowledges at the same time the divine inspiration of Moses, and expresses a laudable indignation at the impiety of those who have treated the sacred narrative with disrespect. *Succensere non possum*, says the divine, *ex Patribus et auctoribus antiquis illis, qui in symbola aut parabolas aut sermones populares hæc convertere studuerunt. Succenseo autem Celso, qui anilem fabulam,* μυθον τινα ὡς γραυσι διηγουμενον, *hanc narrationem appellat. Ubi recte monet, per modum responsi Origines,* ὅτι μετα τροπολογιας ταυτα ειρηται. "I cannot be displeased with those Fathers of the church, and other ancient writers who have treated the Mosaic account of the creation as a popular story or parable, but I am undoubtedly displeased with Celsus, who has called it an old woman's story, which imputation Origen has satisfactorily answered by observing that these things are to be understood *tropically*." Dr. Burnet's *Archæologiæ Philosophicæ*, lib. ii. cap. 7.

THE ANIMAL FUNCTIONS.

THE ANIMAL FUNCTIONS.

CHAPTER XVI.

ON THE BRAIN AND NERVOUS SYSTEM IN GENERAL.

§ 203. This class of functions which constitutes the leading character of animals, and has derived its name from that circumstance, affords to our observation a more clear and manifest gradation, from the most simple to the most compound structure, than any others in the animal economy.*

§ 204. In some of the most simple animals of the class *vermes,* particularly among the *zoophytes,* little or no distinction of similar parts † or structures can be discerned; and we are unable to recognize any thing as a particular nervous system, or even as a part of such a system. The power of sensation and voluntary motion, which these possess, as well as any other order or class of the animal kingdom, prove that the nervous matter must be uniformly spread throughout their homogeneous substance. The almost transparent polypes, (*hydræ*) which are often found in this country, (Germany) with a body of an inch in length, and arms, or tentacula, of a proportionate size, appear to consist, when surveyed in the best light by the strongest magnifying power, of nothing but a granular structure, (something similar to boiled sago) connected into a definite form by a gelatinous substance.

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* An ingenious attempt to establish a new classification of animals, according to the general organization of the nervous system, has been made by Rudolphi, in his *Beyträge zur Anthropologie und allgemeine Naturgeschichte.* Berl. 1812, p. 79.

Much instructive information on this subject, particularly with reference to the brain of warm-blooded animals, will be found in Gall and Spurzheim's *Anatomie et Physiologie du Systeme Nerveux.* Par. 1810, 4to.

See J. and C. Wenzel *De structura cerebri humani et brutorum.* Tubing. 1812, fol.; and several other works on this subject, which I have enumerated in the fourth edition of my *Institutiones Physiologicæ,* 1821, p. 176.

† By the term *partes similares,* the ancients denoted those homogeneous organic structures which form nerves, muscles, tendons, bones, cartilages, &c.; the combination of which constitutes the *partes dissimilares* of the animal body, i. e. the limbs, viscera, &c.

§ 205. In many other *vermes*, and in *insects*, a ganglionic system of nerves can be distinguished, arising in general from what is called the spinal marrow, the superior extremity of which part, slightly enlarged, constitutes the brain. The latter organ, however, in both classes of cold and red blooded animals, and still more in those which have warm blood, has a much more complicated structure, and a far greater relative magnitude: all animals are however exceeded in both these points by the human subject, which, according to the ingenious observation of the learned Sömmering,* possesses by far the largest brain in proportion to the size of the nerves which arise from it.

The small size of the brain in proportion to the rest of the nervous system has a very considerable influence on the whole animal economy of cold-blooded, when viewed in comparison with warm-blooded animals. It explains the diminished sympathy between the two parts; and the consequently weak powers of motion in their whole machine. It enables us also to understand the remarkable independence of the vitality of their parts upon that of the brain, and their possession of considerable individual powers of life, as also the extraordinary extent of their reproductive powers.†

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* See his *Dissertatio de basi Encephali*. Goetting. 1778, p. 17; and his *Tabula baseos Encephali*. Francof. 1799, p. 5; also J. G. Ebel, *Observ. Neurol. ex Anatome comparat*. Francof. ad Vadrum, 1788.

† I have treated at greater length on all these points in my *Specimen Physiologiæ comparatæ inter Animantia calidi et frigidi Sanguinis*, in the 8th vol. of the Goettingen Commentaries; and in the *Handbuch der Naturgeschicte*, p. 225.

The vast superiority of man over all other animals in the faculties of the mind, which may be truly considered as a generic distinction of the human subject, led physiologists at a very early period to seek for some corresponding difference in the brains of man and animals. They naturally investigated the subject in the first instance, by comparing the proportion which the mass of the brain bears to the whole body; and the result of this comparison in the more common and domestic animals was so satisfactory that they prosecuted the inquiry no further, but laid down the general proposition, which has been universally received since the time of Aristotle, that man has the largest brain in proportion to his body. Some more modern physiologists, however, in following up this comparative view in a greater number of animals, discovered several exceptions to the general position. They found that the proportion of the brain to the body in some birds exceeds that of man, and that several mammalia (some *quadrumana*, and some animals of the *mouse* kind) equal the human subject in this respect.

As these latter observations entirely overturned the conclusion which had been before generally admitted, Sömmering has furnished us with another point of comparison, that has hitherto held good in every instance: viz. that of the ratio which the mass of the brain bears to the nerves arising from it.

Let us divide the brain into two parts; that which is immediately connected with the sensorial extremities of the nerves, which receives their impressions, and is therefore devoted to the purposes of animal existence. The second division will include the rest of the brain, which may be considered as connecting the functions of the nerves with the faculties of the mind. In proportion then as any animal possesses a larger share of the latter and more noble part; that is, in proportion as the organ of reflexion exceeds that of the external senses, may we expect to find the powers of the mind more vigorous and more clearly developed. In this point of view man is decidedly pre-eminent: here he excels all other animals that have hitherto been investigated.

The brain of man is much larger than that of the simiæ, when compared with the size of the nerves which proceed from it; this may be readily seen by looking at the comparative breadth of the cerebral nerves and brain in man and different animals. The size of the brain, as compared with that of the medulla spinalis in man, is larger than in *simiæ*, as may be perceived on comparing the transverse diameter of the spinal marrow below the corpora pyramidalia with the whole breadth of the cerebrum. The size of the brain in *simiæ* and the *seal* is larger in proportion than in other animals. The classes of animals whose cerebrum is next in size, are the *lemures, cetacea, ruminantia, multungula, solidungula, feræ, et bradypoda.* The cerebrum is smallest in the *glires, marsupialia, edentata,* and *chiroptera.* The cerebellum of *simiæ* presents but few differences from that in man. In one species, *saimiri*, it is greater than in man; and in a number of instances the ratio is the same or nearly the same; for example, in the *ox* it is the same; in the *cat*, various *monkeys*, and in the *horse*, it is nearly the same. (Vid. Warren *on the Sensorial and Nervous Systems, &c.* p. 81.)

The researches of Sömmering on animals in general have led him to conclude that the quantity of brain, over and above that which is necessary for a mere animal existence; that part, in short, which is devoted to the faculties of the mind, bears a direct ratio to the docility of the animal, to the rank which it would hold in a comparative scale of mental powers.

The largest brain which Sömmering has found in a horse, weighed 1 lb. 4 oz.; and the smallest which he has seen in an adult man, was 2 lb. 5½ oz. Yet the nerves arising from the former brain were at least ten times larger than those of the latter.

The following table exhibits the proportions of the mass of the brain to that of the whole body in man and the different classes of animals. It will be observed that, *cæteris paribus*, small animals have a larger brain, in proportion to their size, than larger ones: that the brain of man is exceeded, in proportional size, by some few animals, as *mice*, the *smaller birds*, &c.; that among the mammalia, the *rodentia* have generally the largest, and the *pachydermata* the smallest brain; and that the brain is extremely small in cold-blooded, as compared with warm-blooded animals.

MAMMALIA.

It forms in man from $\frac{1}{22}$, $\frac{1}{25}$, $\frac{1}{30}$, $\frac{1}{35}$, of the body, according to the different periods of his life.

Orang-outangs.

In the Gibbon	$\frac{1}{48}$ of the body.

Sapajous (American Apes).

Saïmiri	$\frac{1}{22}$
Saï	$\frac{1}{25}$
Ouïstiti	$\frac{1}{28}$
Coaïta	$\frac{1}{41}$

African and Indian Apes.

Malbrouk	$\frac{1}{24}$
Callitriche and Patras .	$\frac{1}{41}$
The monk ape	$\frac{1}{44}$
Mangabey	$\frac{1}{48}$

Magots and Macakos.

Macako *(simia silenus)*	$\frac{1}{96}$ of the body.
Magot	$\frac{1}{105}$
Papio	$\frac{1}{104}$

Makis.

Mococo	$\frac{1}{61}$
Vari	$\frac{1}{84}$

Cheiroptera.

Bat	$\frac{1}{96}$

Plantigrada.

Mole	$\frac{1}{36}$
Bear	$\frac{1}{265}$
Hedgehog	$\frac{1}{168}$

Carnivora.

Dog	$\frac{1}{47}$, $\frac{1}{50}$, $\frac{1}{157}$, $\frac{1}{154}$, $\frac{1}{161}$, $\frac{1}{305}$
Fox	$\frac{1}{205}$
Wolf	$\frac{1}{239}$
Cat	$\frac{1}{82}$, $\frac{1}{94}$, $\frac{1}{156}$
Ounce	$\frac{1}{247}$
Pine-martin	$\frac{1}{365}$
Ferret	$\frac{1}{138}$

Rodentia.

Beaver	$\frac{1}{290}$
Hare	$\frac{1}{228}$
Rabbit	$\frac{1}{140}$, $\frac{1}{152}$
Ondatra	$\frac{1}{124}$
Rat	$\frac{1}{76}$
Mouse	$\frac{1}{43}$
Field-rat	$\frac{1}{51}$

Pachydermata.

Elephant	$\frac{1}{500}$

Wild-boar	$\frac{1}{672}$ of the body.
Chinese hog	$\frac{1}{451}$

Ruminantia.

Stag	$\frac{1}{290}$
Roebuck	$\frac{1}{94}$
Sheep	$\frac{1}{351}$, $\frac{1}{192}$
Ox	$\frac{1}{860}$
Calf	$\frac{1}{219}$

Solipeda.

Horse	$\frac{1}{400}$
Ass	$\frac{1}{254}$

Cetacea.

Dolphin	$\frac{1}{25}$, $\frac{1}{36}$, $\frac{1}{66}$, $\frac{1}{102}$
Porpoise	$\frac{1}{93}$

BIRDS.

Eagle	$\frac{1}{260}$
Sparrow	$\frac{1}{25}$
Chaffinch	$\frac{1}{27}$
Redbreast	$\frac{1}{32}$
Blackbird	$\frac{1}{68}$
Canary-bird	$\frac{1}{14}$
Cock	$\frac{1}{25}$
Duck	$\frac{1}{257}$
Goose	$\frac{1}{360}$

REPTILES.

Tortoise	$\frac{1}{2240}$
Turtle	$\frac{1}{5688}$
Coluber natrix	$\frac{1}{792}$
Frog	$\frac{1}{172}$

FISHES.

Shark	$\frac{1}{2496}$
Pike	$\frac{1}{1305}$

Carp	$\frac{1}{560}$
Dog-fish	$\frac{1}{1345}$
Tunny	$\frac{1}{13450}$
Silurus glanis	$\frac{1}{1887}$

The following table shews the proportion of the cerebrum to the cerebellum in man and other mammalia. The *rodentia* have the largest cerebellum in proportion to the cerebrum; and man has the least cerebellum in proportion to the cerebrum of all the mammalia.

In man, the cerebellum is to the cerebrum	1 : 9
Saimiri	1 : 14
Saï.	1 : 6
Magot	1 : 7
Papio	1 : 7
Monk Ape	1 : 8
Dog	1 : 8
Cat	1 : 6
Mole	1 : 4.5
Beaver	1 : 3
Rat	1 : 3.25
Mouse	1 : 2
Hare	1 : 6
Wild Boar	1 : 7
Ox	1 : 9
Sheep	1 : 5
Horse	1 : 7

The proportion of the cerebrum to the medulla oblongata is ascertained by measuring their diameters. Sömmering and Ebel have shewn that it is greater in man than in other animals, and that it furnishes a good criterion of the degree of intelligence in the individual, as it shews the relation which the organ of intelligence bears to the organs of the external senses. There are, however, some exceptions to this rule, as in the remarkable instance of the dolphin. The following table exhibits the proportions between the breadth of the medulla oblongata at its base, and the greatest breadth of the cerebrum in some of the mammalia, and in a few birds.

In man, the breadth of the cerebrum is to that of the medulla oblongata, as	1 : 7
In the Ape	1 : 4
Macako	1 : 5
Dog	6 : 11 or 3 : 8
Cat	4 : 11
Rabbit	3 : 8 or 1 : 3
Pig	3 : 8
Ram	1 : 3
Stag	2 : 5

Roebuck	1 : 3
Ox	5 : 13
Calf	2 : 5
Horse	8 : 21
Dolphin	1 : 13

BIRDS.

Falcon	13 : 34
Owl	14 : 35
Duck	10 : 27
Turkey	12 : 33
Sparrow	7 : 18

The following is the passage to which the author refers in his "*Manual of Natural History.*" "The extraordinary strength of the reproductive power in several amphibia, and the astonishing facility with which the process is carried on, depend, if I mistake not, on the great magnitude of their nerves, and the diminutive proportion of their brain. The former parts are in consequence less dependent on the latter; hence the whole machine has less powers of motion, and displays less sympathy: the mode of existence is more simple, and approaches more nearly to that of the vegetable world than in the warm-blooded classes; but, on the contrary, the parts possess a greater individual independent vitality. Since, in consequence of this latter endowment, stimuli, which operate on one part, or one system, do not immediately affect the whole frame by sympathy, as in warm-blooded animals, we are enabled to explain the peculiar tenacity of life, which is displayed under various circumstances in this class; viz. frogs still continue to jump about after their heart has been torn out; and turtles have lived for months after the removal of the whole brain from the cranium. The long continued power of motion in parts which have been cut off from the body, as in the tail of the water-newt and blind-worm, may be explained upon the same principles." § 98.

MAMMALIA.

§ 206. The two large processes of the dura mater, which form the falx and tentorium, possess a very peculiar structure in some animals of this class. A strong plate of bone, which is a process of the neighbouring bones of the cranium, is contained between their two laminæ.

We have hitherto ascertained only one example of such a formation of the falx, in the quadrupeds of this class; and this I discovered in the *ornithorhynchus*, (Plate I. c.) an anima which abounds in instances of anomalous structure. Something similar is found in the *cetacea,* at least in the *porpoise.* A similar structure, constituting an unique specimen of anatomical variety, is exhibited in the skull of a female, belonging to my collection. The vitreous table of the frontal bone has a long falciform bony crista, at the attachment of the falx. The falx itself descends to various depths between the hemispheres in the different species.*

A bony tentorium cerebelli is found in a great number of mammalia; but its size and extent vary in the different species. It is formed by peculiar osseous plates, extending from the vitreous table of the parietal bones, and the petrous portions of the ossa temporum. Its formation exhibits two kinds of variety.

In some animals, for instance, it constitutes an uniform bony partition, which leaves a quadrangular opening into the lower part of the cranium. This is the case in most species of the *cat* and *bear* kind; in the *martin,* (*mustela martes*) in the *coaita,* (*cercopithecus paniscus*)† and others.

It consists of three separate portions in other animals; one of these pieces projects from the upper and back part of the cranium, like a tile; the two lateral portions arise from the petrous part of the temporal bone. This structure is exemplified in the *seal, dog, horse,* the *orycteropus capensis,* and *didelphis wombat.*

In the cranium of a young seal which I possess, the anterior or upper surface of the tile-shaped piece is connected by means of a strong perpendicular bony plate, extending to the middle of the lambdoid suture, with the inner surface of the occipital bone, where the falx terminates.

In some cases, as in the *pig,* the *rabbit,* some *mice,* &c., a rudiment of the last mentioned lateral portions may be observed; or at least the ridge of the petrous portion of the temporal bone is much larger than usual. I have, in another place, described the chief varieties of the bony tentorium, and have mentioned the uses possibly assigned to this structure.*

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* See on this subject Sömmering, *Vom Hirn und Buchenmark.* Mentz, 1788.

† Josephi's *Anatomie der Saügethiere Beytr. zum* 1 *sten* b. s. 34, tab. 4.

"It is difficult (says the author, in his *Manual of Osteology*) to give a physiological explanation of the use of this bony tentorium. The opinion which has been generally adopted by anatomists, that the structure in question belongs to such animals only as jump far, or run with great velocity, and that it serves the purpose of protecting the cerebellum from the pressure of the cerebrum in these quick motions, is obviously unsatisfactory. It exists in the bear, which is not distinguished for its activity, while several animals, which excel in jumping or springing, do not possess it; viz. the wild goat, (*capra ibex*) in which I could not discover the least trace of such a structure. Cheselden ascribes it to predacious animals only, (*Anat. of the Bones*, cap. 8) but I have already enumerated several others. It may perhaps obviate the concussion which would arise from strong exertions in biting; for such exertions are made in all the animals which possess this structure, even by the horse in his wild state." p. 118.

I have quoted these remarks on the generally assigned use of the bony tentorium, because a similar mechanical explanation has been given of the falx and tentorium of the human subject; viz. that the former protects the hemispheres from mutual pressure when the person lies with his head resting on one side; and that the latter provides against the compression of the cerebellum by the superincumbent cerebrum. These explanations are assigned in the present day by anatomists of such distinguished reputation as Sömmering and Cuvier (*De Corporis Humani Fabrica*, vol. iv. p. 27. *Leçons d'Anat. compar*. tom. ii. p. 178). If the futility of this piece of physiology were not sufficiently proved by considering that the cranium is accurately filled, and that there is consequently no room for its contents to fall from one side to the other, it must immediately be rendered manifest by Mr. Carlisle's case; in which the falx was entirely absent, and the two hemispheres united throughout in one mass, without any perceptible inconvenience during the patient's life. (*Transactions of a Society for the Improvement of Medical and Chirurgical Knowledge*, vol. ii. p. 212.) In four instances the anterior half of the falx has been found deficient. This production of the dura mater commenced in a narrow form about the middle of the sagittal suture; and, gradually expanding, had acquired the usual breadth at its termination in the tentorium. The two hemispheres adhered by the pia mater covering their opposed plane surfaces; but were formed naturally in other respects. A want of the falx has also been recorded by Garengeot (*Splanchnologie*, tom. ii. p. 24).

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* See the *Osteologische Handbuch*, s. 117, and the *Institutiones Physiologicæ*, p. 174.

§ 207. The peculiarities which distinguish the brain of the human subject from that of the mammalia,* consist chiefly in the circumstance, which has been already noticed, of its possessing a much greater bulk in proportion to the nerves which arise from it; and in its being much larger when compared with the cerebellum and medulla spinalis.†

The anatomy of the brain of cetaceous animals has not been so minutely described as that of other classes of animals. In general, the brain of the cetaceous tribe is small compared with the size of the body. The brain of a common *whale*, nineteen feet in length, which was examined by Seoresby, weighed about three pounds and three quarters, although the weight of the animal was near 11,200 pounds. Here the weight of the brain was about $\frac{1}{3000}$ part of that of the body, whilst that of the brain of an adult man is about four pounds, and that of the body 140, the brain being the $\frac{1}{35}$ part of the weight of the whole body. Professor Tiedemann, of Heidelberg, has recently published an account of the dissection of the brain of the *dolphin*. (Treviranus's and Tiedemann's *Zeitschrift fur Physiologie*, vol. ii. p. 255.) The following are the results of this learned anatomist's investigations.

1. The cerebrum of the *dolphin* resembles that of the simiæ, by its size, and next to the cerebrum of the orang-outang, most resembles that of man. Still in proportion to the size of the nerves, spinal marrow, and cerebellum, it is of much smaller size than the human cerebrum.

2. Each hemisphere of the cerebrum, as in man and *simiæ*, consists of three lobes, an anterior, middle, and posterior. The hemispheres

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* The reader may consult the following delineations of the brain of *mammalia*, besides those which will be referred to in subsequent notes. Of the chimpansé (*simia troglodytes*) by Tyson, in his excellent *Anatomy of a Pigmy*, fig. 13, 14. Of other *quadrumana*, and of numerous quadrupeds of the different species of mammalia, Tiedemann, *Icones cerebri Simiarum et quorundam Animalium rariorum*. Heidelb. 1821. Of the *dog*, by Collins, *System of Anatomy*, vol. ii. tab. 53, fig. 1; and Ebel, *loc. cit.* tab. 1, fig. 7. Of the *cat*, by Collins, tab. 53, fig. 2; and Ebel, tab. 1, fig. 3. Of the *horse*, by Vicq d'Azyr, *Mém. de l'Acad. des Sciences*, 1783, tab. 7; Ebel, tab. 1, fig. 1. Of the *sheep*, by Vicq d'Azyr, tab. 8, fig. 1; and Ebel, tab. 1, fig. 8. Of the *ox*, Vicq d'Azyr, tab. 8, fig. 2; Ebel, tab. 1, fig. 6 and 9. Of the *pig*, Collins, tab. 54; Ebel, tab. 1, fig. 10. Of the *elephant*, Camper, tab. 14. Of the *seal*, Vrolek, *De phocis, speciatim de phoca vitulina*. Ultraj. 1822, tab. 1.

† The delineation which I have given of the brain of the mandrill, (*papio maimon*) in the two first editions of my work, *De Generis Humani Varietate Nativa*, tab. 1, fig. 1, shews how striking this difference is, even in the *quadrumana*, which from their great general resemblance to the human subject have been called *Anthropomorpha*.

are undoubtedly much smaller than those in man, since they do not completely cover the cerebellum.

3. The breadth of the cerebrum of the *dolphin* exceeds its length, which is scarcely the case with any other mammalia.

4. The convolutions of the cerebrum of the *dolphin* are more numerous than in any other animal, even than in man.

5. The lateral ventricles consist in the *dolphin*, as in *man* and *simiæ*, of three horns, whilst in other mammalia the anterior and middle cornua only exist.

6. The *corpora albicantia*, in the cerebrum of the *dolphin*, as of most mammalia, are united into one mass. In man and the *orang-outang* they are perfectly distinct.

7. The fornix, septum lucidum, cornua ammonis, and corpora striata, are in proportion to the size of the cerebrum of the *dolphin*, and smaller than the same parts in man.

8. The corpora quadrigemina in the *dolphin*, as in other mammalia, are much larger than these bodies in man.

9. The cerebellum of the *dolphin* is distinguished by its being larger than in man; and its middle portion, as in *seals* and several other animals, is not symmetrical.

10. The medulla oblongata of the *dolphin* possesses no trapezium.

11. The brain of the *dolphin* is particularly distinguished from that of man and all other mammalia, by the absence of the olfactory nerves. But on the whole the brain of the *dolphin* is developed in a greater degree than in any other animal, if we except that of the *orang-outang*.

§ 208. Moreover, that remarkable and enigmatical collection of sandy matter, which is found in the pineal gland[*] of the human brain, almost invariably after the first few years of existence, has been hitherto observed in very few other mammalia, and those among the *bisulca*.[†]

§ 209. In the proper quadrupeds (the *quadrumana* therefore being excepted) the anterior lobes of the brain form two large processes, (*processus mamillares*)[‡] from which the olfactory nerves of the first pair proceed. These are of very considerable magnitude, particularly in the herbivorous animals.* They contain a continuation of the lateral ventricle; which circumstance has formerly given rise to great physiological errors.†

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[*] Sömmerring *De lapillis, vel prope, vel intra Glandulam pinealem sitis.* Mentz, 1785, 8vo.

[†] Sömmerring has found it in the *fallow-deer*, (*cervus dama*) see his *Diss.* p. 10; and Malacarne in the *goat*, *Encephalotomia di alcuni Quadrupedi.* Mant. 1795, 4, p. 31.

[‡] See Metzger *Specimen Anatomiæ comparatæ primi paris Nervorum*, in his *Opusc. Anat. and Physiol.* Göthing. 1790, 8vo. p. 100.

§ 210. The structure of the *corpora quadrigemina* and *candicantia* distinguishes the brain of herbivorous from that of carnivorous quadrupeds. The *nates* very considerably exceed the *testes* in size, in the former class, while these proportions are reversed in the latter instance. The herbivora have a single large *eminentia candicans*; there are two small ones in the carnivora. ‡

With the exception of man and the simiæ, the mammalia cannot be said to have posterior lobes of the brain. The cerebellum is seen behind the cerebrum. The consequence of this is, that the digital cavity, or prolongation of the lateral ventricle into the posterior lobe, is wanting.

The convolutions of the cerebrum do not exist in the *rodentia*. The *simiæ* only have an olfactory nerve, arising, like that of man, in a distinct chord from the brain. Other mammalia have a large cortical eminence (*processus mamillaris*) filling the ethmoidal fossa. As the *cetacea* have no organ of smelling, their brain has neither olfactory nerve, nor mamillary process.

The annexed tables representing the dimensions of the cerebrum, cerebellum, corpora quadrigemina, medulla oblongata, and medulla spinalis, calculated to five decimal parts of the French metre, in the four classes of vertebrated animals, are taken from the celebrated work of M. Serres *sur l'Anatomie comparée du Cerveau dans les quatre Classes des Animaux vertébrés.*

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* This part is represented in the *bisulca*, and in the *hare-kind*, in Collins's *System of Anatomy*, vol. ii. tab. 51. Ebel, *loc. cit.* Willis, *Anatome Cerebri*, fig. 2. Monro *On the Nervous System*, tab. 9 and 24.

† These were first refuted by that excellent anatomist, C. V. Schneider, of Wittenberg. See his classical work *De Osse cribriformi*, 1635, 12mo.

‡ Sömmerring, *Vom Hirn*, &c. p. 91.

DIMENSIONS
OF
THE LOBES OF THE CEREBRUM IN MAMMALIA.

	MEASURES Of the Lobes of the Cerebrum.		
	Antero-posterior diameter.	Transverse diameter.	Vertical diameter.
	Metre.*	Metre.	Metre.
Man	0,17000	0,07500	0,09000
NAMES OF ANIMALS.			
Simia rubra (red ape of Senegal)	0,07700	0,03300	0,05600
S. sylvanus (Barbary ape)	0,07200	0,02950	0,04300
S. cynocephalus (dog-faced baboon)	0,07000	0,02825	0,04500
S. sphynx (long-tailed baboon)	0,08200	0,03400	0,05700
S. maimon (mandrill)	0,08100	0,03200	0,04900
S. apella (sajou)	0,05900		0,04300
Lemur macaco (maki vari)	0,04500	0,02125	0,02900
Ursus arctos (brown bear)	0,09300	0,04300	0,06100
U. Americanus (American black bear)	0,08300	0,03650	0,04800
U. lotor (racoon)	0,05000	0,02150	0,02900
U. meles (badger)	0,05400	0,02400	0,03200
Viverra narica (brown civet)	0,04900	0,01850	0,03150
Mustela foina (martin)	0,03900	0,01700	0,02400
M. lutra (otter)	0,05200	0,02400	0,03400
Canis familiaris (domestic dog)	0,06000	0,02950	0,04400
C. lupus (young wolf)	0,05600	0,02550	0,03200
C. vulpes (fox)	0,03600	0,01750	0,02800
C. hyæna (hyæna)	0,06600	0,02950	0,04100
Felis leo (lion)	0,09100	0,04050	0,04800
F. tigris (tiger)	0,09400	0,04250	0,06400
F. onça (jaguar)	0,08100	0,03250	0,04800
F. pardus (panther)	0,07800	0,03400	0,05000
F. discolor (couguar, or American lion)	0,07100	0,02950	0,04200
F. lynx (lynx)	0,06100	0,02750	0,04200
Phoca vitulina (common seal)	0,10100	0,04900	0,04400
Didelphis Virginiana (opossum)	0,02200	0,01050	0,01450

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* The French metre is equal to 3 feet 1½ nails, English.

Dimensions of the Lobes of the Cerebrum in Mammalia.

[Continued.]

NAMES OF ANIMALS.	MEASURES Of the Lobes of the Cerebrum.		
	Antero-post. diameter.	Transverse diameter.	Vertical diameter.
	Metre.	Metre.	Metre.
Macropus major (kangaroo)	0,05300	0,02350	0,03800
Phascolomys (wombat)	0,04400	0,02100	0,02750
Castor fiber (beaver)	0,04200	0,02400	0,02700
M. alpinus (marmot of the Alps)	0,02975	0,01466	0,01950
Sciurus vulgaris (squirrel)	0,02025	0,01150	0,01400
Cavia acuti (agouti)	0,03500	0,01550	0,02200
Dasypus sexcinctus (armadillo)	0,02650	0,01300	0,01700
Sus tajassu (pecari)	0,06600	0,02450	0,03700
Hyrax capensis (marmot of the Cape)	0,03300	0,01250	0,02100
Camelus dromedarius (dromedary)	0,10500	0,05050	0,05800
C. llacma (lama)	0,08000	0,03450	0,04500
C. capreolus (roebuck)	0,06200	0,02600	0,04300
Common sheep	0,05800	0,02650	0,04300
Delphinus delphis (dolphin)	0,09500	0,05850	0,08200
D. phocæna (porpoise)	0,08600	0,06650	0,05000

DIMENSIONS
OF
THE CEREBELLUM IN MAMMALIA.

	MEASURES Of the Cerebellum.	
	Transverse diameter.	Antero-post. diameter.
	Metre.	Metre.
Man	0,12000	0,06000
NAMES OF ANIMALS.		
Simia rubra (red ape of Senegal)	0,04500	0,02433
S. sabæa (callitriche).	0,03100	0,01800
S. sylvanus (Barbary ape)	0,03900	0,02400
S. cynocephalus (dog-faced baboon) . . .	0,03800	0,02000
S. sphynx (long-tailed baboon)	0,04200	0,02650
S. maimon (mandrill)	0,05166	0,02900
S. apella (sajou)	0,03600	0,02400
Lemur macaco (maki)	0,03050	0,02200
Rhinolophus unihastatus (horse-shoe bat) . .	0,00900	0,00500
Vespertilio murinus (rear mouse)	0,00800	0,00400
Talpa Europæa (mole)	0,01400	0,00925
Ursus arctos (brown bear)	0,06200	0,03400
U. Americanus (American black bear) . . .	0,05900	0,03500
U. lotor (racoon)	0,03100	0,01900
U. meles (badger)	0,03800	0,02100
Mustela foina (martin)	0,02800	0,01450
M. martes (pine-martin)	0,02400	0,01400
M. lutra (otter)	0,02300	0,01800
Canis familiaris (domestic dog)	0,04200	0,02525
C. lupus (young wolf)	0,03400	0,01700
C. hyæna (hyæna)	0,04000	0,02100
Felis leo (lion)	0,05500	0,03200
F. tigris (tiger)	0,05300	0,03900
F. onça (jaguar)	0,05400	0,03550
F. pardus (panther)	0,04850	0,03200
F. discolor (couguar, or American lion) . .	0,04900	0,02500
F. lynx (lynx)	0,03900	0,02650

Dimensions of the Cerebellum in Mammalia.

[Continued.]

NAMES OF ANIMALS.	MEASURES Of the Cerebellum.	
	Transverse diameter.	Antero-post. diameter.
	Metre.	Metre.
Phoca vitulina (common seal)	0,07250	
Didelphis Virginiana (opossum)	0,02000	0,01200
Macropus major (kangaroo)	0,03800	0,02600
Phascolomys (wombat)	0,02200	0,01800
Castor fiber (beaver)	0,03500	0,02000
Mus typhlus (blind rat)	0,01300	0,00700
M. alpinus (marmot of the Alps)	0,02450	0,01200
Hystrix cristata (crested porcupine)	0,03000	0,01800
Lepus cuniculus (rabbit)	0,01600	0,00900
Cavia acuti (agouti)	0,02300	0,01700
Dasypus sexcinctus (armadillo)	0,02500	0,01300
Sus tajassu (pecari)	0,03500	0,02200
Hyrax capensis (marmot of the Cape)	0,01400	0,01400
Camelus dromedarius (dromedary)	0,07100	0,04600
C. llacma (lama)	0,04900	0,03400
C. capreolus (roebuck)	0,03900	0,03200
Capra hircus (goat)	0,04400	0,03900
Common sheep	0,03000	0,02700
Delphinus delphis (dolphin)	0,08500	0,04500
D. phocæna (porpoise)	0,07800	0,03300

DIMENSIONS

OF

THE CORPORA QUADRIGEMINA IN MAMMALIA.

	MEASURES Of the Corp. Quad.	
	Transverse diameter.	Antero-post. diameter.
	Metre.	Metre.
Man.	0,01000	0,01100
NAMES OF ANIMALS.		
Simia rubra (red ape of Senegal)	0,00625	0,00900
S. sabæa (callitriche)	0,00600	0,00750
S. Faunus (malbrook)	0,00700	0,00833
S. sylvanus (Barbary ape)	0,00650	0,00900
S. silenus (wanderow)	0,00575	0,00800
S. cynocephalus (dog-faced baboon)	0,00600	0,00733
S. sphynx (long-tailed baboon)	0,00625	0,01000
S. maimon (mandrill)	0,00650	0,01000
S. capucina (sai)	0,00450	0,00850
Lemur macaco (maki)	0,00550	0,00925
Rhinolophus unihastatus (horse-shoe bat)	0,00300	0,00300
Vespertilio murinus (rear mouse)	0,00250	0,00250
Talpa Europæa (mole)	0,00333	0,00500
Ursus arctos (brown bear)	0,00850	0,01200
U. Americanus (American black bear)	0,00875	0,01200
U. lotor (racoon)	0,00625	0,00900
U. meles (badger)	0,00600	0,01000
Mustela foina (martin)	0,00566	0,00800
M. martes (pine-martin)	0,00550	0,00725
M. lutra (otter)	0,00500	0,00800
Canis familiaris (domestic dog)	0,00700	0,00975
C. lupus (young wolf)	0,00700	0,00950
C. hyæna (hyæna)	0,01000	0,01275
Viverra civetta (civet)	0,00775	0,00950
V. genetta (genet-cat)	0,00650	0,00875
Felis leo (lion)	0,01200	0,01700
F. tigris (tiger)	0,01000	0,01300

Dimensions of the Corpora Quadrigemina in Mammalia.

[Continued.]

NAMES OF ANIMALS.	MEASURES Of the Corp. Quad.	
	Transverse diameter.	Antero-post. diameter.
	Metre.	Metre.
F. onça (jaguar)	0,00950	0,01200
F. pardus (panther)	0,00950	0,01200
F. paradalis (ocelot)	0,00775	0,01250
F. discolor (couguar, or American lion)	0,01000	0,01200
F. jubata (Indian tiger)	0,00850	0,01150
F. lynx (lynx)	0,00900	0,01200
F. catus (cat)	0,00900	0,01200
Phoca vitulina (common seal)	0,00950	0,01500
Didelphis Virginiana (opossum)	0,00600	0,00750
Macropus major (kangaroo)	0,00800	0,01400
Phascolomys (wombat)	0,00700	
Castor fiber (beaver)	0,00700	0,01000
Mus typhlus (blind rat)	0,00400	0,00600
M. alpinus (marmot of the Alps)	0,00550	0,00900
Hystrix cristata (crested porcupine)	0,00600	0,00875
Lepus cuniculus (rabbit)	0,00425	0,00700
Cavia acuti (agouti)	0,00550	0,00700
C. paca (paca)	0,00775	
C. Cobaya (Guinea-pig)	0,00400	0,00750
Dasypus sexcinctus (armadillo)	0,00550	0,00650
Sus tajassu (pecari)	0,00850	0,01500
S. scropha (wild boar)	0,01000	0,01500
Hyrax capensis (marmot of the Cape)	0,00450	0,00700
Equus caballus (horse)	0,01950	0,02275
Camelus dromedarius (dromedary)	0,01250	0,02125
C. llacma (lama)	0,01125	0,01800
Antilope kevella (kevel)	0,00950	0,01700
A. gazella (gazelle)	0,00933	0,01475
A. rupicapra (chamois)	0,00925	0,00750
Cervus elaphus (stag)	0,01400	0,02100
C. dama (fallow deer)	0,01300	0,01700

Dimensions of the Corpora Quadrigemina in Mammalia.

[Continued.]

NAMES OF ANIMALS.	MEASURES Of the Corp. Quad.	
	Transverse diameter.	Antero-post. diameter.
	Metre.	Metre.
C. capreolus (roebuck)	0,01050	0,01500
Capra hircus (goat)	0,00800	0,01300
Bos taurus (ox)	0,00900	0,01500
Common sheep	0,00800	0,01400
Delphinus delphis (dolphin)	0,00700	0,02475

DIMENSIONS

OF

THE MEDULLA OBLONGATA IN MAMMALIA.

	MEASURES Of the Medulla Oblongata.
	Metre.
Man	0,02000
NAMES OF ANIMALS.	
Simia rubra (red ape of Senegal)	0,01375
S. sylvanus (Barbary ape)	0,01300
S. cynocephalus (dog-faced baboon)	0,01150
S. nemestrina (maimon)	0,01400
S. rhesus (rhesus)	0,01500
S. sphynx (long-tailed baboon)	0,01400
S. maimon (mandrill)	0,01500
S. leucophea (drill)	0,01450
Lemur macaco (maki)	0,01266
Rhinolophus unihastatus (horse-shoe bat)	0,00450
Vespertilio murinus (rear mouse)	0,00350
Erinaceus Europæus (hedgehog)	0,00700
Talpa Europæa (mole)	0,00700
Ursus arctos (brown bear)	0,02100
U. Americanus (American black bear)	0,02100
U. lotor (racoon)	0,01300
U. meles (badger)	0,01700
Viverra narica (brown civet)	0,01400
V. nasua (red civet)	0,01500
Mustela foina (martin)	0,01300
M. lutra (otter)	0,01300
Canis familiaris (domestic dog)	0,02000
C. lupus (young wolf)	0,01050
C. vulpes (fox)	0,01300
C. hyæna (hyæna)	0,01900
Viverra cafra (civet of the Cape)	0,01000
Felis leo (lion)	0,02400
F. tigris (tiger)	0,02400
F. onça (jaguar)	0,02250
F. pardus (panther)	0,01450

Dimensions of the Medulla Oblongata in Mammalia.

[Continued.]

NAMES OF ANIMALS.	MEASURES Of the Medulla Oblongata.
	Metre.
F. discolor (couguar, or American lion)	0,02150
F. lynx (lynx)	0,01600
Phoca vitulina (common seal)	0,02300
Didelphis Virginiana (opossum)	0,01100
Macropus major (kangaroo)	0,02200
Phascolomys (wombat)	0,01700
Castor fiber (beaver)	0,01600
Mus nitela (lerot)	0,00450
M. typhlus (blind rat)	0,00600
M. alpinus (marmot of the Alps)	0,01200
Sciurus vulgaris (squirrel)	0,00900
Cavia acuti (agouti)	0,01200
Dasypus sexcinctus (armadillo)	0,01500
Sus tajassu (pecari)	0,02100
Hyrax capensis (marmot of the Cape)	0,00950
Equus caballus (horse)	0,03200
E. asinus (ass)	0,02500
E. zebra (zebra)	0,02400
Camelus dromedarius (dromedary)	0,03600
C. llacma (lama)	0,02500
Cervus elaphus (stag)	0,01900
C. capreolus (roebuck)	0,02100
Goat of Upper Egypt	0,01900
Bos taurus (ox)	0,03350
Common sheep	0,01600
Delphinus delphis (dolphin)	0,01900
D. phocœna (porpoise)	0,01600

DIMENSIONS OF THE MEDULLA SPINALIS IN MAMMALIA.

	MEASURES Of the Medulla Spinalis.
	Metre.
Man	0,01100
NAMES OF ANIMALS.	
Simia rubra (red ape of Senegal)	0,00900
S. sylvanus (Barbary ape)	0,00800
S. cynocephalus (dog-faced baboon)	0,00900
S. nemestrina (maimon)	0,00700
S. rhesus (rhesus)	0,00775
S. sphynx (baboon)	0,01000
S. maimon (mandrill)	0,00950
S. leucophea (drill)	0,00800
S. apella (sajou)	0,00550
Lemur macaco (maki)	0,00800
Rhinolophus unihastatus (horse-shoe bat)	0,00200
Vespertilio murinus (rear mouse)	0,00200
Erinaceus Europæus (hedgehog)	0,00400
Talpa Europæa (mole)	0,00350
Ursus arctos (brown bear)	0,01700
U. Americanus (American black bear)	0,01300
U. lotor (racoon)	0,00800
U. meles (badger)	0,00800
Viverra narica (brown civet)	0,00800
V. nasua (red civet)	0,01050
Mustela foina (martin)	0,00700
M. lutra (otter)	0,00750
Canis familiaris (domestic dog)	0,01100
C. lupus (young wolf)	0,00600
C. vulpes (fox)	0,00900
C. hyæna (hyæna)	0,01300
Viverra cafra (civet of the Cape)	0,00650
Felis leo (lion)	0,01700
F. tigris (tiger)	0,01600
F. onça (jaguar)	0,01400

Dimensions of the Medulla Spinalis in Mammalia.

[Continued.]

NAMES OF ANIMALS.	MEASURES Of the Medulla Spinalis.
	Metre.
F. pardus (panther)	0,01300
F. discolor (couguar, or American lion)	0,01200
F. lynx (lynx)	0,01100
Phoca vitulina (common seal)	0,01150
Macropus major (kangaroo)	0,01200
Phascolomys (wombat)	0,00900
Castor fiber (beaver)	0,00800
Mus nitela (lerot)	0,00325
M. typhlus (blind rat)	0,00300
M. alpinus (marmot of the Alps)	0,00450
Sciurus vulgaris (squirrel)	0,00500
Cavia acuti (agouti)	0,00700
Dasypus sexcinctus (armadillo)	0,00900
Sus tajassu (pecari)	0,01050
Hyrax Capensis (marmot of the Cape)	0,00550
Equus caballus (horse)	0,02000
E. asinus (ass)	0,01500
E. zebra (zebra)	0,01400
Camelus dromedarius (dromedary)	0,01900
C. llacma (lama)	0,01200
Cervus elaphus (stag)	0,00800
C. capreolus (roebuck)	0,01300
Goat of Upper Egypt	0,01100
Bos taurus (bull)	0,01900
Common sheep	0,00900
Delphinus delphis (dolphin)	0,01000
D. phocæna (porpoise)	0,00800

BIRDS.

§ 211. The dura mater forms, in some birds, a falciform process; which has been erroneously asserted to be deficient in the whole class.* In the cock of the woods, (*tetrao urogallus*) † it has a bony structure resembling that of the *ornithorhynchus*.

§ 212. The brain itself, considered altogether, resembles that of the former class (even in forming in some instances a kind of *processus mamillares*); while, on the contrary, it is strikingly distinguished from that of the following order. It differs, however, from that of the mammalia, not only in the smoothness of its surface, and the want of convolutions, but also in the structure of the optic thalami. These eminences, which are nearly spherical, and hollow internally, are not contained in the proper brain or cerebrum, but lie behind and below that part. This structure is common to birds with the two classes of cold and red blooded animals. Those eminences also, which in the mammalia are justly termed *corpora striata*, are of an uniform colour in birds.

Cuvier represents the brain of birds to consist of six tubercles, visible exteriorly; viz. the two hemispheres, the optic thalami, a cerebellum, and medulla oblongata.

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* This mistake has even been committed by Haller, *De Partium Corp. Hum. Fabrica et Functionibus*, tom. viii. p. 163.

† The brain of this bird is remarkably small in proportion to the size of its head and whole body; while we know, that in some other animals of this class, particularly among the singing-birds, the brain exceeds that of the human subject in these points of view.

DIMENSIONS

OF

THE LOBES OF THE CEREBRUM IN BIRDS.

NAMES OF BIRDS.	MEASURES Of the Lobes of the Cerebrum.		
	Antero-post. diameter.	Transverse diameter.	Vertical diameter.
	Metre.	Metre.	Metre.
Vultur fulvus (vulture)	0,03200	0,02200	0,01550
Falco fulvus (common eagle)	0,03200	0,02400	0,02100
F. ossifragus (sea eagle)	0,02800	0,01900	0,02100
F. æruginosus (buzzard)	0,01200	0,01400	0,01200
F. buteo (hawk)	0,01700	3,01500	0,01350
F. communis (falcon)	0,01900	0,01450	0,01200
Strix bubo (great horned owl)	0,02500	0,01800	0,02000
Motacilla regulus (gold-crowned wren)	0,09000	0,00600	0,00550
Hirundo rustica (swallow)	0,01000	0,00600	0,00600
Alauda arvensis (lark)	0,01100	0,00700	0,00650
Fringilla domestica (sparrow)	0,01100	0,00650	0,00700
F. cœlebs (chaffinch)	0,01200	0,00700	0,00700
F. linaria (linnet)	0,01150	0,00650	0,00600
F. canaria (canary-bird)	0,01200	0,00600	0,00700
Corvus pica (magpie)	0,02000	0,01400	0,01200
African parrot	0,02900	0,01400	0,01700
Meleagris gallopavo (turkey)	0,01750	0,01250	0,01200
Phasianus gallus (common fowl)	0,01800	0,01200	0,01200
P. nycthemerus (silver pheasant)	0,01475	0,01233	0,01100
Struthio camelus (ostrich)	0,01550	0,01200	0,01200
S. casuarius (cassowary)	0,03800	0,02200	0,02400
Otis tarda (bustard)	0,04500	0,02350	0,02000
Ardea ciconia (white stork)	0,02200	0,01450	0,01400
A. pavonina (royal crane)	0,02400	0,01600	0,01900
Goeland	0,02000	0,01350	0,01300
Pelecanus Bassanus (solan goose)	0,01300	0,02000	0,02100
Anas anser (goose)	0,02500	0,01300	0,01400
A. bernicla (barnacle goose)	0,02700	0,02500	0,01700
A. moschata (musk duck)	0,02460	0,02700	0,01150
A. mollissima (eider duck)	0,02200	0,02450	0,01700

DIMENSIONS
OF
THE CEREBELLUM IN BIRDS.

NAMES OF BIRDS.	MEASURES Of the Cerebellum.	
	Transverse diameter.	Antero-post. diameter.
	Metre.	Metre.
F. ossifragus (sea eagle)	0,01050	0,02033
F. æruginosus (buzzard)	0,01400	0,01250
F. buteo (hawk)	0,01500	0,01600
Strix ulula (owl)	0,01125	0,01400
Motacilla regulus (gold-crowned wren)	0,00300	0,00400
Hirundo urbica (swallow)	0,00500	0,00600
Alauda arvensis (lark)	0,00700	0,00500
Fringilla domestica (sparrow)	0,00500	0,00525
F. cœlebs (chaffinch)	0,00600	0,00400
F. linaria (linnet)	0,00650	0,00500
F. canaria (canary-bird)	0,00500	0,00525
F. carduelis (goldfinch)	0,00500	0,00400
Loxia chloris (greenfinch)	0,00600	0,00575
Corvus pica (magpie)	0,01100	0,01150
C. corax (crow)	0,01100	0,01300
Amazonian parrot	0,01700	0,01300
African parrot	0,01300	0,01200
Turtle-dove	0,00900	0,01000
Meleagris gallopavo (turkey)	0,01350	0,01600
Phasianus gallus (common fowl)	0,00900	0,01100
P. nycthemerus (silver pheasant)	0,01100	0,01025
P. pictus (golden pheasant)	0,01200	0,01100
Tetrao cinereus (partridge)	0,01075	0,00950
Struthio camelus (ostrich)	0,01750	0,02500
S. casuarius (cassowary)	0,01900	0,02200
Otis tarda (bustard)	0,00975	0,01800
Ardea pavonina (royal crane)	0,01050	0,01800
Goeland	0,01200	0,01700
Anas mollissima (eider duck)	0,01000	0,01800

DIMENSIONS

OF

THE CORPORA QUADRIGEMINA IN BIRDS.

NAMES OF ANIMALS.	MEASURES Of the Corp. Quad.	
	Transverse diameter.	Antero-post. diameter.
	Metre.	Metre.
Vultus fulvus (vulture)	0,00800	0,01200
Falco chrysaetos (golden eagle)	0,00800	0,01200
F. ossifragus (sea eagle)	0,01100	0,01100
F. communis (falcon)	0,00725	0,00775
F. æruginosus (buzzard)	0,00550	0,00900
F. buteo (hawk)	0,00600	0,00900
Motacilla regulus (gold-crowned wren)	0,00300	0,00250
Hirundo urbica (swallow)	0,00475	0,00450
Alauda arvensis (lark)	0,00425	0,00400
Fringilla domestica (sparrow)	0,00400	0.00350
F. cœlebs (chaffinch)	0,00400	0,00400
F. linaria (linnet)	0,00300	0,00300
F. canaria (canary bird)	0,00325	0,00300
F. carduelis (goldfinch)	0,00325	0,00300
Loxia chloris (greenfinch)	0,00400	0,00350
C. pica (magpie)	0,00600	0,00600
Amazonian parrot	0,00625	0,01000
African parrot	0,00600	0,00700
Meleagris gallopavo (turkey)	0,00725	0,00875
Phasianus gallus (common fowl)	0,00800	0,00900
P. nycthemerus (silver pheasant)	0,00850	0,00900
P. pictus (golden pheasant)	0,00700	0,00800
Struthio camelus (ostrich)	0,01125	0,01100
S. casuarius (cassowary)	0,01000	0,01050
Otis tarda (bustard)	0,00800	0,00775
Ardea ciconia (white stork)	0,00800	0,01200
A. pavonina (royal crane)	0,00900	0,00900
Goeland	0,00800	0,00800

Dimensions of the Corpora Quadrigemina in Birds.

[Continued.]

NAMES OF BIRDS.	MEASURES Of the Corp. Quad.	
	Transverse diameter.	Antero-post. diameter.
	Metre.	Metre.
Pelecanus Bassanus (solan goose)	0,00900	0,01100
Anas anser (goose)	0,00700	0,00850
A. bernicla (barnacle goose)	0,00650	0,00900
A. moschata (musk duck)	0,00800	0,00975
A. mollissima (eider duck)	0,00600	0,00625

DIMENSIONS

OF

THE MEDULLA OBLONGATA IN BIRDS.

NAMES OF BIRDS.	MEASURES Of the Medulla Oblongata.
	Metre.
Vultus fulvus (vulture)	0,01100
Falco chrysaetos (royal eagle)	0,01400
F. ossifragus (sea eagle)	0,01700
F. communis (falcon)	0,00800
F. æruginosus (buzzard)	0,00900
F. buteo (hawk)	0,00900
Strix bubo (great horned owl)	0,00900
Motacilla regulus (gold-crowned wren)	0,00300
Hirundo urbica (swallow)	0,00350
Alauda arvensis (lark)	0,00400
Fringilla domestica (sparrow)	0,00375
F. cœlebs (chaffinch)	0,00450
F. linaria (linnet)	0,00375
F. canaria (canary bird)	0,00300
F. carduelis (goldfinch)	0,00300
Loxia chloris (greenfinch)	0,00400
C. pica (magpie)	0,00800
Amazonian parrot	0,01000
African parrot	0,00900
Meleagris gallopavo (turkey)	0,00950
Phasianus gallus F. (common fowl, hen)	0,01000
Phasianus gallus M. (cock)	0,01100
Capon	0,00800
P. nycthemerus (silver pheasant)	0,01025
P. pictus (golden pheasant)	0,00950
Columba palumbus (pigeon)	0,00600
Tretrao cinereus (grey partridge)	0,00550
Struthio camelus (ostrich)	0,01600
S. casuarius (cassowary)	0,01600
Otis tarda (bustard)	0,01000
Ardea ciconia (white stork)	0,01533
A. nigra (black stork)	0,01400
A. pavonina (royal crane)	0,00900

Dimensions of the Medulla Oblongata in Birds.

[Continued.]

NAMES OF BIRDS.	MEASURES Of the Medulla Oblongata.
	Metre.
Goeland	0,01000
Pelecanus Bassanus (solan goose)	0,01400
Anas anser (goose)	0,01050
A. bernicla (barnacle goose)	0,01100
A. moschata (musk duck)	0,01400
A. boschus (common duck)	0,01400
A. mollissima (eider duck)	0,01100

DIMENSIONS

OF

THE MEDULLA SPINALIS IN BIRDS.

NAMES OF BIRDS.	MEASURES Of the Medulla Spinalis.
	Metre.
Vultus fulvus (vulture)	0,00800
Falco chrysaetos (royal eagle)	0,00800
F. ossifragus (sea eagle)	0,00600
F. communis (falcon)	0,00500
F. æruginosus (buzzard)	0,00550
F. buteo (hawk)	0,00400
Strix bubo (great horned owl)	0,00600
Motacilla regulus (gold-crowned wren)	0,00125
Hirundo urbica (swallow)	0,00175
Alauda arvensis (lark)	0,00225
Fringilla domestica (sparrow)	0,00175
F. cœlebs (chaffinch)	0,00233
F. linaria (linnet)	0,00150
F. canaria (canary bird)	0,00150
F. carduelis (goldfinch)	0,00200
Loxia chloris (greenfinch)	0,00200
C. pica (magpie)	0,00450
Amazonian parrot	0,00400
African parrot	0,00400
Meleagris gallopavo (turkey)	0,00500
Phasianus gallus F. (common fowl, hen)	0,00425
Phasianus gallus M. (cock)	0,00475
P. nycthemerus (silver pheasant)	0,00550
P. pictus (golden pheasant)	0,00500
Columba palumbus (pigeon)	0,00400
Tetrao cinereus (grey partridge)	0,00300
Struthio camelus (ostrich)	0,00700
S. casuarius (cassowary)	0,00800
Otis tarda (bustard)	0,00600
Ardea ciconia (white stork)	0,00750
A. nigra (black stork)	0,00700
A. pavonina (royal bird)	0,00500
Goeland	0,00500

Dimensions of the Medulla Spinalis in Birds.

[Continued.]

NAMES OF BIRDS.	MEASURES Of the Medulla Spinalis.
	Metre.
Pelecanus bassanus (solan goose)	0,00750
Anas anser (goose)	0,00600
A. bernicla (barnacle goose)	0,00600
A. moschata (musk duck)	0,00700
A. boschus (common duck)	0,00675
A. mollissima (eider duck)	0,00600

§ 213. The brain of birds does not possess several parts, which are found in that of the mammalia, and the opinions of anatomists are much divided concerning others, on account of variations in their structure and appearance. The corpus callosum, pons varolii, &c. come under the description of parts, which are certainly absent. The existence of the fornix, pineal gland, corpora candicantia and quadrigemina, is a matter of dispute.*

AMPHIBIA.

§ 214. Anatomists have hitherto bestowed but little labour, comparatively speaking, on the brain of *amphibia.* It is small and simple, and consists of five roundish eminences; viz. the two hemispheres, the two thalami nervorum opticorum, lying behind these, and separate from them, and excavated by a ventricle; and the cerebellum, which in both classes of cold red-blooded animals contains no arbor vitæ. The spinal marrow, compared with the brain, is of astonishing magnitude in most amphibia.†

The dura matter forms no processes in the amphibia, nor in the fishes.

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* See Haller's valuable observations, *de cerebro avium,* in the *Opera Minora,* vol. iii.; and Malacarne's long commentary on them in the three first volumes of the *Memorie della Società Italiana.*

Several authors have given representations of the brain of birds. That of the *goshawk,* the *owl,* the *finches,* (*fringillæ*) the *pigeon,* the *partridge,* and the *goose,* has been delineated by Ebel, *loc. citat.*

That of the *kingfisher,* the *red bird,* (*loxia cardinalis*) the *turkey,* the *bustard,* the *woodcock, snipe,* and others of the genus *scolopax,* the *swan, goose,* and *duck,* by Collins, *loc. citat.* tab. 49, 56, 57, and 58.

That of the *raven* and *common cock* by Vicq d'Azyr, in the *Mémoires de l'Acad. des Sciences,* 1783, tab. 9 and 10.

That of the *goose* in a lateral and internal view, by Ludwig, *De Cinerca Cerebri Substantia.* Lips. 1779, 4to. fig. 1.

† The brain of the *tortoise* has been delineated by Caldesi, in his *Observations,* &c. tab. 2, fig. 5. That of the *frog* by Ludwig, Vicq d'Azyr, and Ebel, *locis citatis;* and that of the *viper* by Vicq d'Azyr, tab. 10, fig. 8.

DIMENSIONS

OF THE

LOBES OF THE CEREBRUM IN REPTILES.

NAMES OF ANIMALS.	MEASURES Of the Lobes of the Cerebrum.	
	Antero-post. diameter.	Transverse diameter.
	Metre.	Metre.
Testudo græca (tortoise)	0,01600	0,00500
T. mydas (green turtle)	0,01900	0,01000
Crocodilus Niloticus, (common crocodile)	0,00800	0,00500
Adult crocodile	0,01800	0,01500
C. sclerops (alligator)	0,00700	0,00400
C. lucius (pike-headed alligator)	0,02100	0,01100
L. agilis (grey lizard)	0,00500	0,00275
Lacerta viridis (green lizard)	0,00350	0,00250
Tupinambis	0,00400	0,00300
L. Africana (common chameleon)	0,00600	0,00333
Anguis fragilis (blind-worm)	0,00250	0,00200
Amphisbæna	0,00500	0,00300
Coluber beras (adder)	0,00400	0,00300
Ringed snake	0,00550	0,00400
C. hajé (hajé viper)	0,00575	0,00400
Rana esculenta (common frog)	0,00500	0,00400

DIMENSIONS

OF

THE CEREBELLUM IN REPTILES.

NAMES OF ANIMALS.	MEASURES Of the Cerebellum.	
	Transverse diameter.	Antero-post. diameter.
	Metre.	Metre.
Testudo græca (tortoise)	0,00400	0,00300
T. mydas (green turtle)	0,01125	0,01100
Crocodilus Niloticus (common crocodile)	0,00500	0,00400
C. sclerops (alligator)	0,00400	0,00300
C. lucius (pike-headed alligator)	0,01400	0,01000
L. agilis (grey lizard)	0,00150	0,00150
Lacerta viridis (green lizard)	0,00175	0,00150
Tupinambis	0,00350	0,00500
L. Africana (common chameleon)	0,00375	0,00175
Anguis fragilis (blind-worm)	0,00100	0,00100
Coluber beras (adder)	0,00200	0,00233
Ringed snake	0,00175	0,00200
C. hajé (hajé viper)	0,00175	0,00200
Rana esculenta (common frog)	0,00300	0,00200

DIMENSIONS

OF THE

CORPORA QUADRIGEMINA IN REPTILES.

NAMES OF ANIMALS.	MEASURES Of the Corp. Quad.	
	Transverse diameter.	Antero-post. diameter.
	Metre.	Metre.
Testudo græca (tortoise)	0,00200	0,00350
T. mydas (green turtle)	0,00700	0,00650
Crocodilus Niloticus (common crocodile)	0,00300	0,00350
C. sclerops (alligator)	0,00225	0,00275
Lacerta viridis (green lizard)	0,00150	0,00150
L. agilis (grey lizard)	0,00175	0,00150
Tupinambis	0,00250	0,00300
L. Africana (common chameleon)	0,00300	0,00250
Anguis fragilis (blind-worm)	0,00100	0,00100
Coluber natrix (ringed snake)	0,00200	0,00300
Coluber beras (adder)	0,00200	0,00300
Ringed viper	0,00225	0,00300
C. hajé (hajé viper)	0,00200	0,00200
Ranae sculenta (common frog)	0,00300	0,00400

DIMENSIONS

OF

THE MEDULLA OBLONGATA IN REPTILES.

NAMES OF ANIMALS.	MEASURES Of the Medulla Oblongata.
	Metre.
Testudo græca (tortoise)	0,00500
T. mydas (green turtle)	0,01050
Crocodilus Niloticus (common crocodile)	0,00500
C. sclerops (alligator)	0,00425
Lacerta viridis (green lizard)	0,00250
L. agilis (grey lizard)	0,00200
Tupinambis	0,00333
L. Africana (common chameleon)	0,00400
Anguis fragilis (blind-worm)	0,00225
Crotalus horridus (rattle-snake)	0,00700
Coluber beras (adder)	0,00325
Ringed viper	0,00350
C. hajé (hajé viper)	0,00300
Rana esculenta (common frog)	0,00400

DIMENSIONS

OF

THE MEDULLA SPINALIS IN REPTILES.

NAMES OF ANIMALS.	MEASURES Of the Medulla Spinalis.
	Metre.
Testudo græca (tortoise)	0,00300
T. radiata (striped turtle)	0,00500
T. mydas (green turtle)	0,00500
Crocodilus Niloticus (common crocodile)	0,00300
C. sclerops (alligator)	0,00250
Lacerta viridis (green lizard)	0,00175
L. agilis (grey lizard)	0,00166
Tupinambis	0,00200
L. Africana (common chameleon)	0,00225
Anguis fragilis (blind worm)	0,00133
Coluber natrix (ringed snake)	0,00125
Crotalus horridus (rattle-snake)	0,00400
Coluber beras (adder)	0,00200
Ringed viper	0,00150
C. hajé (hajé viper)	0,00175
Rana esculenta (common frog)	0,00300

FISHES.

§ 215. In this class of animals the brain does not fill the cranium. Between the pia and dura mater (which in most of the large fishes approaches to a cartilaginous firmness) there is collected a salt and greasy fluid, contained in a loose cellular texture, which seems to supply the place of the tunica arachnoidea.*

§ 216. The structure of the brain varies in the different genera and species; sometimes even in the individuals of the same species. It consists of several tubercles or lobuli disposed in pairs; and of these, the five, which were described in the brain of the *amphibia,* are the most constant.†

§ 217. In most fishes the optic nerves decussate (just like two fingers laid crosswise), a remarkable peculiarity, which has given rise to several physiological investigations and inferences.‡

In the *skate,* the right nerve goes through a fissure in the left; in bony fishes the decussation is more manifest, as one nerve merely lies on the other without any intermixture of substance. The fact has been noticed by Collins, Willis, and several others; it is represented by Ebel in the *pike, carp,* and *silurus glanis* (*Obs. Neurol. ex Anat.*

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* Casserius has given an excellent view of the cranium of a pike laid open, *De Auditu,* tab. 12.

† Haller, *De Cerebro Piscium,* in the *Opera Minora,* tom. iii. p. 198. Collins has given representations of the brain in almost all the orders of fishes; but his views are chiefly of the upper external surface, tab. 60 to 70. That of the *skate* is delineated in the 2nd vol. of Camper's *smaller writings,* tab. 3; by Monro, in his *Physiology of Fishes,* tab. 1, 34, and 37; and by Scarpa, *De Auditu et Olfactu,* tab. 1, fig. 1. That of the *shark,* by Stenonis, *Elementa Myolog.* tab. 5 and 7, and by Scarpa, *loc. citat.* tab. 2. That of the *frog-fish,* (*lophius piscatorius*) by Camper *loc. citat.* tab. 1.

That of the *congor-eel, turbot,* and *pike,* by Vicq d'Azyr, *loc. citat.* tab. 10. Tha of the *cod,* by Camper, *loc. citat.* and Monro. That of the *haddock,* by Monro, *O* *the Nervous System,* tab. 32. That of the *silurus,* by Ebel, *loc. cit.* tab. 2, fig. 4 That of the *pike* by Casserius, Ebel, and Scarpa, *locis citatis.* That of the *carp* b Ebel and Scarpa.

‡ See Sömmering, in the *Hessischen Beyträge zur Gelehrsamkeit,* vol. i. pt. 2, p. 205 also his *Dissert. de Decussatione Nervor. Opticor.* Mogunt. 1786, p. 24. Coopman *Neurolog.* p. 38. Professor Rudolphi, in Wiedemann's *Archives,* vol. i. part ii. 156, and several of the delineations quoted in the preceding note.

comp. tab. 2, fig. 2, 3, and 4; this dissertation is contained in the 3rd vol. of Ludwig's *Scriptores Neurol. Minores*). It does not seem to have been much investigated in birds and the amphibia. In eight instances, where the eye of an animal had been destroyed or injured, the optic nerve was found to be altered in structure and appearance as far as the union; and beyond that point the alteration extended along the opposite nerve to the opposite thalamus. (See Ebel, *loc. cit.* tab. 1, fig. 1 and 2.) A similar appearance has been found in a man. Sömmering *De Decussat. Nerv. Optic.* in Ludwig's Collection, tom. i.

These nerves have in some fishes the uncommon structure of an investment of pia mater, containing very elegant longitudinal folds.*

The olfactory nerve sometimes forms a ganglion just before it is distributed to the nose. The *gadus merluccius* and the *carp*† afford examples of this structure, which is remarkable, inasmuch as no ganglia have been hitherto observed in the nervous system of fishes.

§ 218. We must lastly mention those nerves which are distributed in the electrical fishes, to that wonderful apparatus of membranous cells, filled with a gelatinous substance like white of egg, and performing the office of a Leyden jar, or electrical battery. These curious organs occupy the lateral fins of the torpedo,‡ and receive their nervous supply from the fifth pair. In the *electrical eel*, (*gymnotus*) the electrical organ is found towards the posterior part of the abdomen,§ and its nerves come from the medulla spinalis. In the *silurus electricus* it is placed between the skin and muscles over the whole body, and its nerves are derived from the eighth pair.‖

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* See Eustachii, *Ossium Examen*, p. 227, and a representation from the saw-fish, (*squalus pristis*) in Malpighi, *De Cerebro*. In order to compare this with the ordinary structure of other nerves, see the representation of the physiological preparation of the commencement of the fifth pair in the elephant, in A. K. Boerhaave *Historia anatomica infantis, cujus pars Corporis inferior monstrosa*. Petersburg, 1754, 4to. tab. 1.

† Scarpa, *loco citato*.

‡ Hunter, in the *Philos. Trans.* vol. lxiii. p. 481, tab. 20; and Girardi, in the *Memorie della Società Italiana*, tom. iii. p. 553.

§ Hunter, in the *Philos. Trans.* vol. lxv. p. 395, tab. 9.

‖ Geoffroy, in the *Bulletin de la Société Philomatique*, 6 année, tom. iii. p. 169.

DIMENSIONS
OF
THE CEREBRUM IN FISHES.

NAMES OF FISHES.	MEASURES Of the Cerebrum.	
	Antero-post. diameter.	Transverse diameter.
	Metre.	Metre.
Petromyzon fluvialis (lesser lamprey)	0,00400	0,00300
Squalus carcharias (white shark)	0,02300	0,01100
S. acanthius (aguilat)	0,01100	0,01000
S. griseus (grey shark)	0,03000	0,01600
S. glaucus (blue shark)	0,01700	0,00700
Raya clavata (ray)	0,01500	0,01300
R. rubus (red ray)	0,01650	0,01300
Acipenser sturio (sturgeon)	0,00600	0,00550
Esox lucius (pike)	0,00700	0,00550
Cyprinus carpio (carp)	0,00600	0,00500
C. tinca (tench)	0,00400	0,00300
Gadus morrhua (cod)	0,00725	0,00800
G. eglefinus (haddock)	0,00100	0,00100
G. merlangus (whiting)	0,00500	0,00400
Pleuronectes maximus (turbot)	0,00600	0,00450
Muræna anguilla (eel)	0,00400	0,00300
M. conger (congor eel)	0,00750	0,00600
Trigla lyra (flying-fish)	0,00600	0,00500
Lophius piscatorius (frog-fish)	0,00400	0,00300

DIMENSIONS
OF
THE CEREBELLUM IN FISHES.

NAMES OF FISHES.	MEASURES Of the Cerebellum.	
	Transverse diameter.	Antero-post. diameter.
	Metre.	Metre.
Petromyzon fluvialis (lesser lamprey)	0,00225	0,00100
Squalus carcharias (white shark)	0,01700	0,03100
S. acanthias (aguilat)	0,01500	0,01700
S. griseus (grey shark)	0,02700	0,02200
S. glaucus (blue shark)	0,01075	0,02100
Raya clavata (ray)	0,03400	0,02500
R. rubus (red ray)	0,02000	0,03500
Acipenser sturio (sturgeon)	0,01300	0,01600
Esox lucius (pike)	0,00600	0,00633
Cyprinus carpio (carp)	0,00675	0,00800
C. tinca (tench)	0,00500	0,00550
Gadus morrhua (cod)	0,01350	0,01700
G. eglefinus (haddock)	0,00800	0,01000
G. merlangus (whiting)	0,00600	0,00625
Pleuronectes maximus (turbot)	0,00750	0,00900
Muræna anguilla (eel)	0,00600	0,00450
M. conger (congor eel)	0,01075	0,00900
Trigla lyra (flying-fish)	0,00900	0,00633
Lophius piscatorius (frog-fish)	0,00700	0,00400

DIMENSIONS

OF

THE CORPORA QUADRIGEMINA IN FISHES.

NAMES OF FISHES.	MEASURES Of the Lobes of the Cerebellum.	
	Transverse diameter.	Antero-post. diameter.
	Metre.	Metre.
Petromyzon fluvialis (lesser lamprey)	0,00200	0,00233
Squalus carcharias (white shark)	0,00700	0,01800
S. acanthias (aguilat)	0,00600	0,01075
S. griseus (grey shark)	0,01100	0,01700
S. glaucus (blue shark)	0,00633	0,01250
Raya clavata (ray)	0,00900	0,01500
R. rubus (red ray)	0,00800	0,01900
Acipenser sturio (sturgeon)	0,00350	0,00650
Esox lucius (pike)	0,00575	0,00800
Cyprinus carpio (carp)	0,00700	0,00900
C. tinca (tench)	0,00400	0,00600
Gadus morrhua (cod)	3,00800	0,00800
G. eglefinus (haddock)	0,00600	0,00900
G. merlangus (whiting)	0,00433	0,00575
Pleuronectes maximus (turbot)	0,00433	0,00675
Muræna anguilla (eel)	0,00350	0,00300
M. conger (congor eel)	0,00600	0,00650
Trigla lyra (flying-fish)	0,00800	0,00850
Lophius piscatorius (frog-fish)	0,00500	0,00600

DIMENSIONS

OF

THE MEDULLA OBLONGATA IN FISHES.

NAMES OF FISHES.	MEASURES Of the Medulla Oblongata.
	Metre.
Petromyzon fluvialis (lesser lamprey)	0,00400
Squalus carcharias (white shark)	0,01400
S. acanthias (aguilat)	0,00900
Raya clavata (ray)	0,01800
R. rubus (red ray)	0,01600
Acipenser sturio (sturgeon)	0,00850
Esox lucius (pike)	0,00900
Cyprinus carpio (carp)	0,00600
C. tinca (tench)	0,00550
Gadus morrhua (cod)	0,01000
G. eglefinus (haddock)	0,00650
G. merlangus (whiting)	0,00600
Pleuronectes maximus (turbot)	0,00800
P. solea (sole)	0,00500
Muræna anguilla (eel)	0,00600
M. conger (congor eel)	0,01100
Perca fluviatilis (perch)	0,00550
Trigla lyra (flying-fish)	0,00700
Lophius piscatorius (frog-fish)	0,00800

DIMENSIONS

OF

THE MEDULLA SPINALIS IN FISHES.

NAMES OF FISHES.	MEASURES Of the Medulla Spinalis.
	Metre.
Petromyzon fluviälis (lesser lamprey)	0,00275
Squalus carcharias (white shark)	0,00700
S. acanthias (aguilat)	0,00600
Raya clavata (ray)	0,00900
R. rubus (red ray)	0,00600
Acipenser sturio (sturgeon)	0,00400
Esox lucius (pike)	0,00600
Cyprinus carpio (carp)	0,00200
C, tinca (tench)	0,00300
Gadus morrhua (cod)	0,00575
G. eglefinus (haddock)	0,00500
G. merlangus (whiting)	0,00300
Pleuronectes maximus (turbot)	0,00500
P. solea (sole)	0,00233
Muræna anguilla (eel)	0,00250
M. conger (congor eel)	0,00700
Perca fluviatilis (perch)	0,00200
Trigla lyra (flying-fish)	0,00400
Lophius piscatorius (frog-fish)	0,00400

INSECTS.

§ 219. The general structure of the nervous system in this class has been already mentioned (§ 204).

The larvæ, in which the subject has been most completely investigated,* have a brain, consisting of two ganglia, contained in a horny cavity larger than itself. The nervous cord, which in red-blooded animals constitutes the medulla spinalis, proceeds from this point along the abdomen, forming in its passage twelve simple ganglia, from which, and from the two ganglia forming the brain, the nerves derive their origin.†

VERMES.

§ 220. Excepting those animals which inhabit corals, and the proper zoophytes, most genera of the other orders of this class are found to possess a distinct nervous system ;‡ although former anatomists have expressly declared, in several instances, that no such parts existed.* The structure and distribution of the nerves possess in many cases a surprising analogy to those of insects. The nervous system of the sea-mouse, (*aphrodite aculeata*) for example, is very similar to that of the larvæ.† In others it is more anomalous: thus, in the cuttle-fish, two large nervous chords arise from the brain, and form in the breast two club-shaped ganglia; from which numerous nerves proceed.‡

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* See Lyonet's excellent account of the larva of the *Phalæna Cossus*, tab. 9, 10, and 18. That of the silkworm by Swammerdam, tab. 28, fig. 3, (which is better than Malpighi's representation) and by Bibiena, in the *Comment. Instit. Bonon.* tom. v. pt. 1, tab. 4. That of the butterfly, by Bibiena, ibid.

† The nervous system of the larva of the *stag-beetle*, may be seen in Swammerdam, tab. 28, fig. 1 ; and in Röesel, tom. ii. tab. 8. That of the *ephemera*, in Swammerdam, tab. 14, fig. 1, tab. 15, fig. 6. That of the male bee, ibid. tab. 22, fig. 6. That of the *musca chamæleon*, in the different stages of its metamorphosis, ibid. tab. 40, fig. 5, tab. 41, fig. 7. That of the larva of the *musca putris*, ibid. tab. 43, fig. 7. That of the louse, tab. 2, fig. 7. That of the lobster, Willis *De Anima Brutorum*, tab. 3, fig. 1.

Humboldt's *Verzuche über die gereizte Muskel und Nervenfase*, vol. i. contain several excellent anatomical and physiological remarks on the nervous system of some insects, pp. 273, 286.

‡ See Jos. Mangili *De Systemate Nerveo Hirudinis, Lumbrici Terrestris, aliorumque Vermium.* Ticini, 1795.

The nervous system of the leech has been shewn by Redi, *De Viventibus intra Viventia*, tab. 14, fig. 9 ; and Bibiena, *Comment. Instit. Bonon.* tom. vii. tab. 2, fig. 5, tab. 3, fig. 6. Bening's excellent work on the leech ; and Mangili's book may also be consulted.

The nerves of the slug are represented by Swammerdam, tab. 9, fig. 2 ; and those of the *helix pomatia*, ibid. tab. 4, fig. 6 ; tab. 6, fig. 1 ; which may be compared with the drawing by Spallanzani, in the *Memorie della Società Italiana*, tom. ii. pt. 2, p. 545.

In the class of insects, and of vermes, the upper ganglion of the nervous chord, which represents the brain, is usually placed near the mouth or œsophagus; which tube is surrounded by a nervous chord proceeding from that ganglion.

In the first volume of the work of M. Serres, *l'Anatomie comparée du Cerveau*, which obtained the prize adjudged at the Royal Institute of France, in 1821, the Report of Baron Cuvier, on that production, is inserted. That report contains, in the form of aphorisms, the substance of M. Serres's work, which, proceeding from so distinguished an anatomist, cannot fail to form a valuable appendix to this section on the brain and nervous system.

The spinal marrow is developed before the brain in all classes.

It consists first, in young embryos, of two cords, which are not united posteriorly; between these two portions a sulcus is left. These two cords soon approximate and join at their posterior part; the interior, therefore, of the spinal marrow is hollow. This canal, which may be designated by the name of ventricle, or canal of the spinal marrow, is sometimes filled with a liquid, constituting dropsy of the spinal marrow; this disease is of frequent occurrence in the embryos of mammalia.

The canal becomes obliterated at the fifth month of the human embryo, and the sixth of those of the *cow* and *horse*, the twenty-fifth day in the embryo of the *rabbit*, and the thirtieth in those of the *cat* and *dog*. It is found in the *larvæ* of *frogs*, until the anterior and posterior limbs appear.

This obliteration takes place in all these embryos by the deposition of successive layers of grey matter, secreted by the *pia mater* which passes into this canal.

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* See the remarks of Humboldt, in his work above quoted, p. 259; and Cuvier's classical work, which I here quote once for all, tom. ii. p. 298.

† Pallas, *Miscellanea Zoologica*, tab. 7, fig. 13.

‡ Swammerdam, tab. 52, fig. 2. Monro, *On the Physiology of Fishes*, tab. 41, fig. 3. Scarpa, *loc. citat.* tab. 4, fig. 7. Tilesius, in Isenflamm and Rosenmuller's *Beyträge zur die Zergliederungskunst*, vol. i. pt. 2, tab. 2.

The spinal marrow in young embryos of all classes, is of the same size throughout its whole extent; there is no enlargement either anteriorly or posteriorly, as is the case with reptiles deprived of limbs (vipers, adders, blind-worms,) and most fishes.

Embryos, which want the enlargements of the spinal marrow, are deprived of their anterior and posterior extremities. The embryos of all mammalia, of birds, and of man, resemble, in this respect, the larvæ of the frog genus in general.

With the appearance of limbs coincides, in all embryos, the appearance of anterior and posterior enlargements of the spinal marrow. This effect is especially remarkable in the larvæ of frogs at the period of its metamorphosis; the embryos of man, mammalia, birds, and reptiles, experience a metamorphosis, entirely analogous to that of the larvæ.

The animals which have only a pair of limbs, have only one enlargement of the spinal marrow; the cetacea particularly are examples of this kind. The enlargement varies in situation according to the place which the pair of limbs occupy on the trunk; the enlargement of the spinal marrow in the genus *bipes* is situated on the posterior parts, in the genus *bimanus*, on the contrary, on the anterior part.

In the cases of monstrosity, which the embryos of mammalia, birds, and man, so often present, there are frequently found bipeds and bimana, which, like the cetacea and reptiles we have just mentioned, have only one enlargement, situated very near the pair of limbs which remains.

The spinal marrow of fishes is slightly enlarged very near the place which corresponds to their fins. Hence the *jugular* have this enlargement behind the head, at the cervical region of the spinal marrow, the *pectoral*, near the middle part, or dorsal, and the *abdominal*, near the abdominal region of the spinal marrow.

The *flying-fish* is remarkable on account of the detached rays of its pectoral, as also by a series of enlargements proportioned, both in number and in size, to the size and number of these same rays to which they correspond.

The electrical fish has a considerable enlargement, corresponding to the nerve which is distributed to the electrical apparatus, (*ray silurus electricus*).

The class of birds presents very remarkable differences in the proportion of these two enlargements.

The birds which live on the earth, as our domestic birds, and those which climb trees, have the posterior enlargement much greater than the anterior. The ostrich is a remarkable instance of this kind.

The birds which fly in the air, and which often make long journeys, present an inverse arrangement; viz., the anterior enlargement exceeds the posterior.

M. Gall said that the spinal marrow was enlarged at the origin of each nerve; M. Serres does not think that this opinion is confirmed by the examination of the spinal marrow of vertebrated animals, at whatever period of life, whether intra or extra uterine, they are considered.

M. Gall thought these enlargements were analogous to the double series of ganglia, which are substituted for the spinal marrow in articulated animals.

This analogy is found, as some authors have already observed, not in the spinal marrow, but in the intervertebrated ganglia.

These ganglia, which have not much engaged the attention of anatomists, are proportioned in every class to the size of the nerves which traverse them. They are much larger near the nerves which go to the limbs, than in any other part.

The spinal marrow is extended to the extremity of the coccyx, in the human fœtus, till the third month. At this period it is on a level with the body of the second lumbar vertebra, where it is inserted at birth.

The human fœtus has a cauda equina, which remains till the third month of uterine life; at this period this prolongation disappears, and its disappearance coincides with the ascent of the spinal marrow in the vertebral canal, and the absorption of a part of the vertebræ of the coccyx.

If the ascent of the spinal marrow be arrested, the human fœtus is born with a tail, which is exemplified by a great number of cases; the coccyx is then composed of seven vertebræ.

There is then a relation between the ascent of the spinal marrow in its canal, and the cauda equina of the human fœtus and of mammalia.

The more the spinal marrow rises in the vertebral canal, the more the cauda equina diminishes, as in the pig, the wild-boar, the rabbit; on the contrary, the more the spinal marrow is prolonged, and descends in its sheath, the more the tail increases in size, as in the horse, ox, and squirrel.

The embryo of bats without a tail resembles, in this respect, that of man; it has at first a tail, which it quickly loses, because, in these mammalia, the ascent of the spinal marrow is very rapid, and proceeds to a considerable height.

This change is very remarkable in the larvæ of frogs, the larvæ preserves its tail so long as the spinal marrow exists in the canal of the coccyx. At the time when the larvæ is about to undergo a metamorphosis, the spinal marrow ascends in its canal, the tail disappears, and the limbs are more and more developed.

If the spinal marrow be arrested in its ascent, the frog preserves its tail as the human fœtus.

The human fœtus, that of bats and other mammalia, undergo a metamorphosis resembling the larvæ of frogs.

In those reptiles which have no limbs, (vipers, adders) the spinal marrow resembles that of the larvæ before its metamorphosis.

In all fishes the spinal marrow presents the same characters; it often presents at its termination a slight enlargement.

Among mammalia, the cetacea resemble fishes in this respect.

The human fœtal monsters, which have no lower extremities, approach, in this respect, cetacea and fishes.

The decussation of the corpora pyramidalia is visible in the human embryo about the eighth week.

In mammalia the decussation becomes less and less apparent on descending from the *quadrumana* to the *rodentia.*

In *birds* there are only observed one or two corpora pyramidalia at farthest, the decussation of which is distinct.

In *reptiles* there is no decussation.

In *fishes* the decussation does not exist.

The size of the spinal marrow and that of the brain are, in general, in inverse ratio one to the other of vertebrated animals.

The human fœtus resembles, in this respect, the inferior classes; the younger the fœtus is, the larger the spinal marrow is and the smaller the brain.

In some circumstances the spinal marrow and brain preserve a direct relation in size; thus, when the spinal marrow is straight, the brain is also straight, which is particularly remarkable in serpents. When the spinal marrow diminishes in length, and increases in size, the brain increases in equal proportions, which is very remarkable in lizards and tortoises.

In *birds,* the more the neck is lengthened the narrower is the spinal marrow, and the more reduced in tissue is the brain.

This direct relation of size between the spinal marrow and the brain, does not apply wholly to the encephalon; it only takes place with respect to the corpora quadrigemina.

The spinal marrow and corpora quadrigemina are exactly developed in direct ratio one to the other, so that the size or *power* of the spinal marrow being given in one class, or in families of the same class, we can exactly determine the size and power of the corpora quadrigemina.

The same observation applies to the human fœtus; the younger it is the stronger is the spinal marrow, and the more the corpora quadrigemina are developed.

The corpora quadrigemina are the first portions of the brain which are formed; their formation always precedes that of the cerebellum, in the embryo of birds, reptiles, mammalia, and man.

In birds the corpora quadrigemina are only two in number; and they occupy, as is well known, the base of the brain.

On the commencement of incubation, they are, as in other classes, situated on the superior surface of the brain, forming at first two lobes, one on each side; on the tenth day of incubation, a transverse sulcus divides this lobe, and at this time there are truly four tubercles situated between the cerebrum and cerebellum.

On the twelfth day a very singular motion begins, by which they pass from the superior towards the inferior surface of the brain.

During this motion the cerebrum and cerebellum, separated at first by these tubercles, approach and terminate by acting against each other, as is observed in all adult birds,

In reptiles, the tubercula quadrigemina are only two in number in the adult state; but on the fifteenth day of the larvæ of frogs, they are divided, as those of the bird, on the tenth day.

In this class the tubercles do not change their place; they always remain situated on the superior surface of the brain, between the cerebrum and cerebellum, and their form is always oval.

In *fishes*, the considerable space which the tubercula quadrigemina occupy, has caused them to be considered, up to the present time, as the cerebral hemispheres of the brain.

That which has contributed to make this error believed is, that they are intercepted by a large ventricle, presenting a considerable enlargement, analogous in its form and structure to the *corpora striata* of the brain in mammalia.

These tubercles are always double in fishes, and their form approaches that of a sphere, slightly flattened internally.

In mammalia and man, the corpora quadrigemina are only two in number during two thirds of the uterine life; they are then oval and hollow internally, as in *birds*, *reptiles*, and *fishes*.

At the last third period of gestation, a transverse fissure divides each tubercle, and then they are only four in number.

The difference which these tubercles present in the different classes of mammalia depends on the position which this transverse sulcus occupies.

In *man* it generally occupies the middle part; the anterior tubercles are almost equal to the posterior.

In the carnivorous animals the sulcus passes more anteriorly, which gives a predominance to the posterior.

In the *ruminantia* and *rodentia* the sulcus passes more posteriorly, which gives a predominance to the posterior.

In some brains of the human fœtus and of mammalia the tubercles remain as they were in their uterine life, namely in two, in which respect they resemble the brain of fishes and reptiles.

The tubercula quadrigemina in man and mammalia are, in the first instance hollow, as in birds, reptiles, and fishes. Their cavity is obliterated in the same manner as the spinal marrow; that is to say, by the deposition of layers of grey matter secreted by the *pia mater*, which passes into its interior.

The corpora quadrigemina are developed in every class, and in families of the same class, in the direct ratio of the size of the optic nerves and eyes.

Fishes have the largest corpora quadrigemina; the optic nerves and eyes are also most developed in this class.

After *fishes* come, in general, *reptiles*, for the size of the eyes, optic nerves, and corpora quadrigemina.

Birds are equally remarkable for the development of their eyes, as also for the size of their optic nerves and corpora quadrigemina.

In mammalia the eyes, optic nerves, and corpora quadrigemina decrease from the rodentia to the ruminantia, from the ruminantia to the carnivorous animals, the quadrumana, and man, who occupies, in this respect, the lowest grade of the animal scale.

As the corpora quadrigemina serve as a base for the determination of the other parts of the brain, we have accumulated all the facts respecting them.

Fishes having the largest corpora quadrigemina, have also the inter-parietal portions the most marked.

After *fishes* come the *reptiles*, then the *birds;* lastly, among mammalia, the rodentia have the greatest inter-parietal portions; then come the ruminantia, the carnivorous animals, the quadrumana, and man, in whom these are only occasionally met with.

It will appear singular that the cerebellum is not formed till after the corpora quadrigemina; but there is no exception to this fact in any class.

In *fishes* the cerebellum is formed of two very distinct portions:

Of a middle lobe, arising from the ventricle of the corpora quadrigemina.

Of lateral layers proceeding from the corpus rectiforme.

These two portions are isolated, disjointed in every class of fishes.

The great difference which the cerebellum of the higher classes presents depends on the union of these two elements, one of which preserves the name of *processus vermiformis superior cerebelli*, and comes, as in fishes, from the corpora quadrigemina; whilst the other, coming from the corpora rectiformia, constitutes the hemispheres of the same organ.

Although united, these two elements are entirely independent of each other.

The processus vermiformis superior cerebelli (middle lobe) and the hemispheres of the same organ are developed in every class in the inverse ratio of each other.

In the families composing the class of mammalia, the same relation is exactly observed; hence the rodentia, the ruminantia, the carnivorous animals, the quadrumana, and man, have this process, and the hemispheres of the cerebellum developed in the inverse ratio of each other.

The spinal marrow is developed in all the classes in direct proportion to the volume of the middle lobes of the cerebrum, and in the inverse ratio of the hemispheres.

These general facts are especially important in estimating the relations of the *tuber annulare.*

The *tuber annulare* is developed in the direct ratio of the hemisphere of the cerebrum, and the inverse ratio of the middle lobe.

The *tuber annulare* is developed in the inverse ratio of the corpora quadrigemina and spinal marrow.

The *thalami nervorum opticorum* do not exist in fishes; that which has been mistaken for them being only an enlargement peculiar to the *corpora quadrigemina.*

In reptiles, birds, mammalia, and man, the size of the thalami is in direct ratio to the size of the cerebral lobes, and the inverse ratio of the corpora quadrigemina.

In the human fœtus the proportion is the same, the corpora quadrigemina decreasing as the thalami increase. In the fœtuses of other mammalia, as well as those of birds and frogs, this inverse proportion also takes place.

The pineal gland exists in the four classes of vertebrated animals; it has two sets of pœdicimale, one coming from the thalami, the other from the corpora quadrigemina.

The corpora striata do not exist in fishes, reptiles, and birds.

In mammalia their development is proportioned to the cerebral hemispheres.

The hemispheres are developed in the direct ratio of the size of the thalami and corpora striata.

In fishes they form a simple rounded bulb, situated in front of the corpora quadrigemina, where the dura cerebri are lost.

In fishes, reptiles, and birds, the cerebral lobes constitute a solid mass without ventricles.

The ventricular cavities are peculiar to mammalia and man.

A curious inverse proportion is observed in this respect between the three inferior classes and mammalia, with respect to the corpora quadrigemina and the cerebral lobes.

In the three inferior classes the corpora quadrigemina have ventricles; the vertebral lobes are solid, and have none.

In the mammalia and man, on the contrary, the corpora quadrigemina are solid, and the cerebral lobes have large ventricles.

In the three inferior classes the cerebral lobes have no convolutions; in the mammalia, on the contrary, the convolutions appear with the cavity of the lobes.

There is no *cornu ammonis* in reptiles, fishes, or birds.

It exists in all the mammalia; it is more developed in the *rodentia* than in the ruminantia, and in the latter than in carnivora, quadrumana, and man.

M. Serres has not met with the hippocampus minor in any class of the mammalia. It is also sometimes wanting in man.

The *fornix* is wanting in fishes and reptiles. It is also wanting in most birds; but a rudiment of it is found in some, as the parrots and eagles.

In the mammalia it is developed in the same proportion as the *cornu ammonis.*

It is larger in the *rodentia* than ruminantia, and in the latter than the carnivora, quadrumana, and man.

There is no appearance of the corpus callosum in the three inferior classes.

The corpus callosum, as well as the pons varolii, are peculiar to mammalia. The corpus callosum is developed in direct proportion to the size of the corpora striata and hemispheres. It increases progressively from rodentia and man.

The corpus callosum is developed in direct proportion to the development of the tuber annulare.

The hemispheres, taken as a whole, are developed in the direct ratio of the hemispheres of the cerebellum, and in the inverse ratio of its superior vermiform process.

The cerebral hemispheres are developed inversely, as the spinal marrow and corpora quadrigemina.

The nerves do not arise from the brain, to be distributed to the different organs of the body, as has been generally supposed; but they proceed from these organs to the brain and the spinal marrow, for the purpose of communicating with these nervous centres.

M. Gall has stated, that the grey is formed before the white matter; this opinion is not correct, as far as the spinal marrow is concerned.

M. Cuvier first proved, that in the genus *asterias* the nervous system is composed of white, without any grey matter.

During the incubation of the chick, the first rudiments of the spinal marrow are observed, composed of white matter; the grey does not appear till a later period.

In the human fœtus, and that of mammalia, the white matter is constantly observed to appear before the grey in the spinal marrow; but in the cerebrum, properly so called, this order, as to the appearance of the two substances, is reversed.

Hence the optic thalami and corpora striata are only enlargements in the young fœtus composed of grey matter; the white not appearing till a later period.

The corpora striata cannot be said to exist in the human fœtus, because the striæ of white matter are not then formed.

The striæ of white matter, which are found in the fourth ventricle of the human subject, do not appear till the twelfth or fifteenth month after birth.

CHAPTER XVII.

ON THE ORGANS OF THE SENSES IN GENERAL, AND ON THAT OF THE SENSE OF TOUCH IN PARTICULAR.

§ 221. Few subjects in comparative anatomy and physiology have given rise to more various and contradictory opinions than the organs of sense in some classes of animals.* Much misunderstanding on this point has clearly arisen from the inconsiderate and unconditional application of inferences drawn from the human subject to animals. Thus it has been supposed that those which possess a tongue, must have it for the purpose of tasting; and that the sense of smell must be wanting, where we are unable to ascertain the existence of a nose. Observation and reflection will soon convince us, that the tongue, in many cases (in the *ant-eaters* among the mammalia, and almost universally in *birds*), cannot from its substance and mechanism be considered as an organ of taste, but must be merely subservient to the ingestion and deglutition of the food. Again, in several animals, particularly among *insects*, an acute sense of smell seems to exist, although no part can be pointed out in the head which analogy would justify us in describing as a nose.

§ 222. However universally animals may possess that feeling, which makes them sensible to the impressions of warmth and cold, very few possess, like the human subject, organs exclusively appropriated to the sense of touch, and expressly constructed for the purpose of feeling, examining, and exploring the qualities of external objects.

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* Much useful information on the organs of sense, and indeed on comparative physiology in general, may be found in F. Boddaert's *Natuurkundigen Beschouwing der Dieren*. Utrecht, 1778, 8vo.; and on the relation of the senses in the different classes of animals, the reader may consult Dr. Troxler's *Versuche in der Organischen Physik*. Jena, 1804, 8vo.

This sense appears, according to our present state of knowledge, to exist only in four classes of the animal kingdom; viz. in most of the mammalia, in a few birds, in serpents, and probably in insects.

MAMMALIA.

§ 223. The structure of the organ of touch is the most perfect, and similar to that of the human subject, in the *quadrumana*. The ends of their fingers, particularly of the posterior extremities, are covered with as soft and delicately organized a skin, as that which belongs to the corresponding parts in man.

Several of the *digitata* are probably provided with this sense. The organization of the under surface of the front toes of the *racoon*, (*ursus lotor*) and the use which the animal makes of those parts, prove this assertion.

It is not so clear that we are authorized in considering the snout of the *mole*[*] and *pig*,[†] not to mention the tongue of the *solidungula* and *bisulca*,[‡] or the snout of these and other animals,[§] as true organs of touch, according to the explanation above laid down. Much less can we suppose the long bristly hairs, which constitute the whiskers of the cat kind, and other mammalia, to be the organs of touch in the sense we are now considering, although they may be serviceable when they come in contact with any object, in warning, and making the animal attentive. The *seal*, for instance, has a very long infra-orbital nerve, consisting of about forty branches, which are distributed to the projecting lip. I have traced many of their terminations to that part of the integuments in which the bulbous roots of their strong whiskers are inserted.*

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[*] Derham's *Physico Theology*, p. 206, not. 60.

[†] Darwin's *Zoonomia*, tom. i. p. 162.

[‡] Buffon, *Histoire des Oiseaux*, tom. i. p. 47.

[§] Buffon, *Histoire Naturelle*, tom. iii. p. 360.

§ 224. There would be more reason for ascribing this sense to the proboscis of the *elephant*, and to the soft, unciform, and always moist point of the upper lip of the *rhinoceros*.

I think, however, that the *ornithorhynchus* clearly possesses an organ of touch. In this curious animal, as in the *duck*, &c., the sense in question resides in the integuments which cover the expanded portion of its jaws, particularly the upper one; this part is most copiously supplied with nerves from the fifth pair, and chiefly from its second branch, distributed just in the same manner as they are on the corresponding parts of the swimming birds.†

Bats have been supposed to possess a peculiar power of perceiving external objects, without coming actually into contact with them. In their rapid and irregular flight amidst various surrounding bodies, they never fly against them; yet it does not seem that the senses of hearing, seeing, or smelling, serve them on these occasions, for they avoid any obstacles with equal certainty when the ear, eye, and nose, are closed. Hence naturalists have ascribed a sixth sense to these animals. It is probably analogous to that of touch. The nerves of the wing are large and numerous, and distributed in a minute plexus between the integuments. The impulse of the air against this part may possibly be so modified by the objects near which the animal passes, as to indicate their situation and nature.

Certain species of apes (*the sapajous*) are furnished with the greatest number of organs of touch; not only are their hands and feet adapted to this sense, but also the lower part of their tails. It must be observed, however, that the fingers of their hands are opposed with difficulty to the thumb, which is sometimes altogether wanting; besides both the toes and fingers are with difficulty separated from each other. With respect to the tail, the number of vertebræ which compose it is greater in a given space than in the same space of the tails of apes which are not prehensile.

Man, who has only a rudiment of the sub-cutaneous tail, and whose feet are formed in a manner peculiarly adapted to the station and progression of a biped, is, with respect to the number of parts formed for the sense of touch, less advantageously furnished than some species of apes; but the deficiency in point of number is recompensed by the perfection of the form of his hand, which enables him to touch a globular surface, in almost all its points, on account of the length of the thumb in proportion to that of the fingers, and the possibility of separating the thumb from the fingers, and the fingers from each other. The structure of the skin is also more perfect, the thickness of the sub-cutaneous adipose substance, the breadth of the extremities of the fingers, the fine texture of the cutis, the size of the nervous papillæ, the thinness of the epidermis, and the size of the nerves at the extremities of the fingers, are all circumstances which give peculiar delicacy and perfection to this organ. Some species of apes, with prehensile tails, possess a similar modification of the organ of touch, but it is confined to the hind feet and tail. Many mammalia have the organ of touch situated in the hips, as the *horse*, in which these parts are much developed, moveable, and furnished with many nerves; or, what is more singular, in the nose, as the *tapir* and *elephant*, the prolonged nose of which latter animal terminates in a flexible, fleshy, papillary edge, without cuticle, divided into two parts, one at the extremity of the nostrils, and the other prolonged to the dorsal or superior line into an appendix shaped like a finger; this is called its trunk.

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* See Darwin, *loc. cit.* Wiedemann, in the *Götting. gel. Anzeigen,* 1798, p. 210. Albers, ibid. 1803, p. 603; and Vrolik, *Ovar het nut der Knevels by viervoetige Dieren.* Amst. 1800, 8vo. Andral, in Majendie's *Journal de Physiol.* tom. ii. p. 74.

† See Plate I. k, l, m, t.

The mole and pig have the nose formed for feeling, but not for distinguishing the shape of external objects.

BIRDS.

§ 225. The structure of the organ of touch in the *ornithorhynchus*, which has been just described, is exactly similar to that of *geese* and *ducks*. The bill of these birds is covered with a very sensible skin, supplied with an abundance of nerves, from all the three branches of the fifth pair.* This apparatus enables them to feel about for their food in mud, where they can neither see nor smell it.

Birds are much less favoured in respect to organs of touch than mammalia; one extremity of their bodies being occupied with the bill, and the other with a sort of oar or rudder. The anterior appendices are organs of mere locomotion, and the remaining portion of the body, or the extremities of the posterior appendices, serve to give them a firm position on their two legs. We find, however, that in these animals the toes are more articulated than in mammalia, that they are in a great degree capable of being separated from each other, that the papillæ of the cutis are well defined, and the nerves with which they are furnished considerable. It may be inferred, therefore, that the feet of birds would be tolerably perfect organs of touch, if they were not used as organs of locomotion, and that the less they are used for the latter purpose, the more perfect would be the sense of touch. Accordingly we find that parrots take up their food with their feet, and convey it to their mouths. In birds of prey the sense of touch is probably more acute, as their feet are little used for progression. In the *gallinaceous birds*, whose feet are constantly on the ground, and in the *ostrich* and *cassowary*, which do not fly, the epidermis is thickened, and its sensibility consequently diminished.

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* See Plate IV. c and f, to o.

AMPHIBIA.

§ 226. It has been said with more of point than of physiological accuracy with respect to serpents,* that their whole body is a hand, by which they gain just notions of the tangible properties of bodies. According to Hellman, who has investigated this subject, their slender bifurcated tongue serves the purposes of touch.†

There are some differences in respect to the degree in which different classes of reptiles may be supposed to possess some approximation to the organ of touch. The land and sea tortoises may be supposed to possess the least sensibility in this respect, on account of the shortness and close junction of their toes. The *crocodiles*, though the structure of their toes is somewhat more adapted to the sense of touch, resembling in this respect the river tortoises, whose toes are well separated, cannot however be supposed capable of feeling the form of external objects. This is the case also with the greater part of the *lizards*, and especially those species which, by the diminution of their members, become almost true *serpents*. Even in those, whose toes are long and separated, the structure of the skin leads us to conclude that they are merely organs of locomotion. In the *geckos*, however, and still more in the *chameleons*, we may suppose the sense of touch to exist, since they clasp the branches of trees with their toes, and even with their tails, which are prehensile. The number of vertebræ which compose the tail of the *chameleon*, are proportionally greater than in a *lizard* of the same size, and the skin which covers both the tail and the toes of that animal seems to be softer than the integuments in other parts of the body.

The great number of vertebræ which form the vertebral column of serpents seems a favourable structure for an organ of touch; but the scaly integuments of these animals renders it improbable that they can judge of the form of external objects. Those species, however, which can climb trees, and coil themselves round the branches of trees, have a structure better adapted to this sense, since they have a greater number of vertebræ in a given space than the other species, especially towards the posterior part of the body.

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* Girtanner, in his exposition of the Darwinian system, pt. 1, p. 124.

† A. Hellman, *über den Tastsinn der Schlangen.* Götting. 1817.

FISHES.

§ 227. Concerning this class it may be remarked, that most of them possess an acute feeling on the abdomen, and in the lips,* analogous, perhaps, to the sense of touch.

INSECTS.

§ 228. All the observations and investigations respecting the structure of the antennæ, those peculiar organs which exist universally in the more perfect insects, and the use which these animals generally apply them to, lead us inevitably to the conclusion, that they really are proper organs of touch; by which the animal examines and explores surrounding objects.† Such organs are particularly necessary to insects, on account of the insensibility of their external coat, which is generally of a horny consistence; and also from their eyes being destitute, in most instances, of the power of motion.

VERMES.

§ 229. It seems more doubtful whether the tentacula of several *vermes*, and particularly the arms of the *cuttle-fish*,‡ can be considered as organs of touch, in the more limited sense to which we have confined that word.§

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* Lacepede, *Histoire Naturelle des Poissons*, tom. i. Discourse, p. 65.

† See Lehmann *De Antennis Insectorum*, Diss. 1, 2. Lond. 1799, 8vo.; and Knock's *Neue Beyträge zur Insectenkunde*, pt. 1. Leipzig, 1801, 8vo. p. 33. Kandohr on the organs of touch in the *bee* in the *Mag. der Berliner Naturf. Freunde.* 1810, p. 287.

‡ Buffon, *Histoire Naturelle*, tom. iii. p. 360.

§ See Lehmann *De Sensibus externis Animalium exsanguium.* Goetting. 1798, 4to. p. 43. F. I. Schelver *Versuch einer Naturgeschicte der Sinneswerkzeage bey den Insecten und Würmen.* Goett. 1798, 8vo. p. 28; and Draparnaud, *Tableau des Mollusques Terrestres et Fluviatiles de la France.* Montpellier, 1801, 8vo. p. 8.

CHAPTER XVIII.

ON THE TONGUE.

§ 230. We are not justified in considering the tongue as an organ of taste in all animals, because it is subservient to that function in the human subject, and in many other instances. We have already observed, that this organ, in many cases, merely serves for taking in the food;* and it is at least very doubtful whether it possesses the sense of taste in several others. Yet, on the contrary, we should not be warranted in denying the existence of the sense in these animals, nor even in such as are entirely destitute of a tongue: for this function may be exercised by other parts. I have seen an adult, and in other respects well-formed man, who was born without a tongue. He could distinguish nevertheless very easily the tastes of solutions of salt, sugar, and aloes, rubbed on his palate, and would express the taste of each in writing. Why then may not those animals, which either have no tongue, or one not calculated for an organ of taste, possess this sense in some of the neighbouring parts? I cannot however agree with that ingenious anatomist Grew,† when he considers the internal surface of the three first stomachs of the *bisulca* to be an organ of taste; particularly since Wepfer and others have remarked the enjoyment which is connected with the second mastication of the food in ruminating animals. Less, however, can be concluded with any certainty *à priori* on this, than on any of the five senses.

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* The lingual bone (*os hyoides*) of the three first classes of animals, varies according to the different methods in which they take their food. Many excellent remarks on this subject may be seen in Fab. ab Aquapendente *De Larynge*, p. 276; and in Casserius *De Vocis Organis*, with excellent delineations.

† See his *Comparative Anatomy of Stomachs and Guts*, p. 26.

MAMMALIA.

§ 231.* No animal possesses a tongue exactly like that of the human subject. The form of the organ differs considerably in the *simiæ*, being longer and thinner; and the papillæ, which cover its upper surface, are very different.

Thus, the length of the tongue of the commonest kind of tailless ape, (*simia sylvanus*) which now lies before me, is three times greater than its breadth. It has three *papillæ petiolatæ*, or *fungiformes*, at its posterior part, arranged in the form of a triangle. Before these, and along the two sides of the tongue, are about two hundred *papillæ obtusæ*, appearing like white grains. These are not all of the same size; but they may be distinguished from the *papillæ conicæ*, which cover the rest of the tongue's superior surface, much more easily than in the human tongue.

§ 232. Most of the herbivorous mammalia, particularly among the *bisulca*, have their tongue covered with a firm and thick cuticular coat, called *epithelium;* which forms numberless pointed papillæ directed backwards. These must assist, according to their consistence and direction, at least in the animals of this country, (Germany) in tearing up the grass. Animals of the cat† kind have their tongue covered with sharp and strong prickles, which must enable the animal to take a firm hold. Similar pointed processes are found in some other animals; as in the *bat-kind*‡ and the *opossum.*

In the tongue of the *opossum* I have found the centre of the anterior extremity beset with strong papillæ, rougher than those which are found in the *cat.*

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* See Reuter *De lingua Mammalium et Avium.* Regiom. 1820.

† Daubenton, vol. ix. tab. 15, of the *panther;* fig. 3 of the *cat;* tab. 22, fig. 2, 3, of the *lynx.*

‡ Ibid. vol. x. fig. 15 of the *vampire.*
Pallas, *Spicileg.* vol. iii. tab. 2, fig. 5, 6, of the *vespertilio cephalotes.*

There seems to be no doubt, that in all the mammalia which we have now considered, the tongue is an organ of taste, at least towards its anterior part.

The toothless animals, on the contrary, as the *ant-eater* and *manis,* which swallow their aliment whole, have a long worm-like tongue, which is obviously capable of no other use than that of taking their food.

The tongue of a two-toed ant-eater, which I dissected, was three inches and a half long, and no larger than a crow-quill at its root. It was, generally speaking, cylindrical, but marked with a scarcely perceptible groove on its superior surface. Two very small foramina cœca were found near the root. The lingual bone was strong, but not remarkably large, and in shape like a horse-shoe. Its muscles, on the contrary, as the geniohyoidei, mylohyoidei, and particularly the genioglossi, were remarkably large and strong.

As we are now considering the tongue in its office of assisting in taking in the food, this seems to be the proper place for noticing the worm, as it is called, (*lytta*) of the dog's tongue. It is a tendinous fasciculus of fibres running lengthwise under the tongue, as far as its apex, and lying rather loose, in a kind of membranous sheath, without being connected, like a true tendon, to any of the neighbouring muscles. By an old prejudice, which has subsisted at least since the time of Pliny, its extirpation is considered as a preservative against hydrophobia.* Casserius thought that it assisted dogs in lapping up fluids in the peculiar way which they do; and his opinion is supported by this circumstance, that an *opossum,* which I kept alive for some time, and which took fluids in the same manner as dogs do, had a similar part under the tongue.

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* Concerning the structure of this curious, and in some respects enigmatical part, see Morgagni *De Sedibus et Causis Morborum,* tom. i. p. 67. Venet. 1761.

BIRDS.

§ 233. All birds possess a tongue, for even the *pelican*, (*onoerotalus*) in which its existence has been denied, possesses a manifest rudiment of the organ. Probably, however, it serves the purpose of an organ of taste in very few genera. Yet this is the case with some predacious and swimming birds, as also with most of the *psittaci;* which possess a soft thick tongue covered with papillæ, and moistened with a salivary fluid; they really taste different fluids, and soft kinds of food, and select that which is the most agreeable.

§ 234. In several other birds, on the contrary, the tongue is horny, stiff, not supplied with nerves, and consequently unfit for an organ of taste. One striking example will supply the place of many. The tongue of the *toucan* (*ramphastos*) is sometimes several inches in length, yet scarcely two lines broad at its root. It has the appearance, throughout, of a piece of whalebone; and its margins are fibrous.

§ 235. The form* and mechanism of the tongue vary much in the different genera and species of this class. Two instances deserve particular notice; that of the *wood-pecker*† and the *cock of the woods.* The tongue of the former bird is generally said to be very long, but it is not so. That part which corresponds to the tongue of other birds, is remarkably short, it is merely a sharp-pointed horny portion, with its sides barbed. Behind this is a very singular os hyoides, of a slender appearance, but having very long crura. It consists of five cartilaginous portions; viz. one single piece and two pairs. In the quiescent state of the organ the former lies in a fleshy and very extensile sheath of the bill. The first pair of cartilages is articulated with this, and they are placed at the sides of the neck. The second pair, commencing from these, run completely over the cranium, under the integuments, and advancing from behind, forwards, their converging extremities are placed together in a kind of groove, and commonly terminate anteriorly, by an attachment to the right side of the upper jaw. This posterior pair of cartilages may therefore be compared to steel springs, which actuate the whole organ. This is an elegant example of the great share which mere elasticity possesses in the performance of some functions of the animal economy. When the tongue is to be darted out, the anterior pieces are drawn together and enter the sheath of the single portion, extended for their reception. The tongue is thus elongated, and admits of being thrust out some inches.*

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* See the plates in J. C. Schoeffer's *Elementa Ornithologica.* Ratisbon, 1774, 4to.

† Huber *De lingua Pici viridis.* Stuttg. 1821.

The tongue of the cock of the woods is still more singular; that organ, together with the larynx, lies deep in the œsophagus, but admits of being quickly elevated and thrust forth by means of considerable muscles.†

AMPHIBIA.

§ 236. We shall select a few examples of the chief varieties in this class of animals.

The *crocodile*'s tongue (the very existence of which has been denied from the time of Herodotus down to Hasselquist) is small, possesses very little motion, and is in a manner adherent between the two sides of the lower jaw.‡ The *salamander* resembles this. A very different structure is presented in the curious tongue of the *chameleon*, the mechanism of which may be compared, in some respects, with that of the *wood-*

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* See Mery, in the *Mémoires de l'Acad. des Sciences*, 1709, p. 85. Waller, in the *Philos. Trans.* vol. xxix. p. 509; and Wolf, in Voigt's *Magazin*, pt. 2, of the new series, p. 468.

† Frisch, *Vögel in Deutschland*, tab. 108. Schneider's *Commentary on the Works of Frederic II.* tab. 2; and Gilibert, *Médecin Naturaliste.* Lyons, 1800, 8vo. p. 294.

‡ C. G. De Rhoer *De Fide Herodoti rite æstimanda*, in the *Verhandelingen van Teylers tweede Genootschap*, pt. 7, p. 104. L. V. Hammen *De Herniis*, p. 105. *Nouvelles de la Republique des Lettres*, Oct. 1688, p. 1125.

pecker. Yet its form is very different; for the anterior extremity of the organ is club-shaped; and is hollowed out on its upper surface.*

The tongue of some testudines is thickly covered on its anterior margin with long fibrous papillæ.†

The soft, flat, and fleshy tongue of the frog, lies, in a quiescent state, in a direction from before backwards. It is firmly attached behind the arch of the lower jaw, and its loose end is turned backwards, so that the semilunar notch of its anterior margin corresponds to the rima glottidis. They seize their prey by turning the tongue forwards, and thrusting it out of the mouth.

The tongue of the chameleon displays a very curious mechanism. It is contained in a sheath at the lower part of the mouth, and has its extremity covered with a glutinous secretion. It admits of being projected to the length of six inches, and is used in this manner by the animal in catching its food, which consists of flies, &c. It is darted from the mouth with wonderful celerity and precision, and the viscous secretion on its extremity entangles the small animals which constitute the food of the chameleon.

§ 237. The tongue of the *serpent* is attached and situated in the same manner as in the *frog*,‡ but it is round and slender, its apex is bifid, and the root rests in a kind of fleshy sheath, being capable of protrusion and retraction at pleasure.§

FISHES.

§ 238. There is little to be said concerning the tongue of this and the two following classes. It is doubtful whether it be an organ of taste, and in what degree it may serve that purpose.*

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* Besides the works which have been already quoted on the anatomy of this animal, see Hussem, in the *Verhandelingen van de Maatschappye te Haarlem*, vol. viii. pt. 2, p. 228. Duvernoy, in the *Bulletin de la Soc. Philom.* tom. iii.; and Miller, *Icones Animal. et Plantar.* tab. 2.

† I have observed this in the *testudo græca* from Mogadore. The form of the os hyoides in the testudines may be seen in Caldesi, tab. 8.

‡ Seetzen, in Meyer's *Zoologisch Archiv.* pt. 2, p. 65.

§ *Abbild. Naturhistorisch. Gegenstände,* pt. 4, tab. 37, in the *boa* and *rattle-snake.* The curious os hyoides of serpents, with two cartilaginous portions running along the trachea, is represented by Tyson, *Philos. Trans.* vol. xiii. p. 68, fig. 5.

It appears at least in fishes to possess no manifest papillæ,† and in many of this class is covered with teeth.

That which is commonly called the tongue, in some fishes, as the carp, is a glandular body attached to the palate, and extremely irritable in the living animal.‡

INSECTS.

§ 239. The organ which is commonly considered as the tongue of insects § merely serves for taking in the food.‖ But the accurate observations of professor Knoch,¶ render it very probable that the posterior pair of palpi, or feelers, possesses the power of taste in several of this class.

VERMES.

§ 240. In the mouth of some mollusca,** and snails, an organ is found, which has generally, from its situation, been taken for the tongue. But none of the observations which have been hitherto adduced respecting its functions, are sufficiently decisive to justify us in setting it down as an organ of taste.

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* See Dumeril, *Mémoires de Zoologie et de l'Anatomie comparée.* Par. 1807.

† Lorenzini's *Osservazioni sulle Torpedini,* p. 41.

‡ *Observat. Colleg. privat. Amstelod.* vol. i. p. 40.

§ Schelver, *loco citato,* p. 39. A. W. Knock, *Neue Beyträge zur Insectenkunde,* pt. 1, 1801, 8vo. p. 40, tab. 1, fig. 30, in which the tongue of the May-beetle (*scarabæus melolontha*) is represented.

‖ *Loc. cit.* p. 32, tab. 1, fig. 9, of the *scarabæus Frischii;* tab. 8, fig. 4, of the *scarabæus unicolor.*

¶ Swammerdam, of the *cuttle-fish,* p. 882, tab. 50, fig. 4, 5.

** Of the *helix pomatia,* ibid. p. 109, tab. 5, fig. 3.

CHAPTER XIX.

ON THE ORGAN OF SMELLING.

§ 241. The sense of smelling prevails much more extensively in the animal kingdom than that of taste, since it not only assists several genera in selecting their food, which they have not afterwards the power of tasting, but is also of service in finding out proper objects for the satisfaction of their sexual appetite. Yet there is much doubt respecting the organs of this sense in the two classes of white-blooded animals.

§ 242.* We can determine the degree of acuteness of this sense by the inspection of the cranium in the four-footed mammalia, (taking the term in its most extensive sense, in which it will include the *quadrumana* and *bats*). Three circumstances principally determine our judgment on this point.

1st, The structure of the ethmoid bone, and particularly the number and arrangement of those openings in its superior or horizontal lamina, which transmit the filaments of the olfactory nerve. 2ndly, The formation of the inferior conchæ narium, or turbinated bones. 3rdly, The existence and relative magnitude of those cavities of the internal nose, particularly the frontal sinuses, which contribute to the organ of smelling.

§ 243. The *hedgehog* and *mole*, the animals of the *weasel*, *bear*, *dog*, and *cat-kinds*, most of the *bisulca*, and the *elephant*, afford examples of a very complicated formation of the ethmoid bone, both in regard to the elegant structure of its cribriform lamella, and to the wonderful convolutions of its turbinated portions, which procure as large a surface as possible within the confined space of the nasal cavity, for the application of the Schneiderian membrane. All these animals are well known for the remarkable acuteness of their sense of smelling.

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* F. C. Rosenthal, *Diss. de Organo Olfactus quorundam Animalium.* Jena, 1802, 4to; and *Gryphiæ*, 1807.

The ethmoid bone is remarkably narrow, and imperfectly developed in most of the *quadrumana*. As there is not sufficient space left for it between the orbits, which lie close together, (§ 21)* it is placed deeper in the nose, so that the olfactory nerves descend between the orbital portions of the frontal bone, as in a canal, the bottom of which is formed by the cribriform lamella, small and inconsiderable, and perforated by few apertures.†

The *cetacea* have no ethmoid bone; and it is a matter of doubt what pair of nerves contribute to the function of smelling.

At the time when the author first published this work, he, as well as other zootomists, believed that the cetaceous animals had no olfactory nerves. Blainville and Jacobson, however, believe that they have found them in the *dolphin* (*delphinus delphis*) situated in the same part of the brain as in the human subject. See the *Bulletin de la Société Philom.* 1815, p. 195. Treviranus has also delineated and described them in his *Biologie*, vol. v. p. 342; but Otto and Rudolphi, who have had frequent opportunities of examining the brain of *dolphins* and *Greenland whales*, have not been able to detect the first pair, and doubt their existence in those animals.

§ 244. The *conchæ narium inferiores* are more or less convoluted, in proportion to the greater or less complication in the structure of the upper ones. They are remarkably large in the *bisulca*;‡ and much convoluted in most of the predacious animals.* They are both large and wonderfully complicated in the seal.

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* In the skull of a *cercopithecus capucinus* in my possession, the partition between the two orbits, which space in the human cranium is filled by the ethmoid cells, and superior turbinated bones, contains a large opening, which in the recent state was probably closed by a portion of periosteum.

† Josephi, *Anatomie der Säugethiere*, vol. i. p. 179, &c.

‡ See Caspar Bartholin, *Analecta Observationum*, in his *Specimen Historiæ Anatomicæ*, tab. 3, fig. 3, 4, of the *sheep*; and Morand, in the *Mém. de l'Acad. des Sciences*, an 1724, tab. 24, of the *ox*. Sir B. Harwood's *System of comparative Anatomy*. Camb. 1796.

§ 245. The frontal sinuses of the *elephant*† are larger than those of any other animal; the *pig*, which has an acute sense of smelling, comes next in order in this respect. I have considered, in a more detailed manner, the structure of these cavities in several genera and species of the different orders of mammalia in my *Prolusio de Sinubus Frontalibus*, Goetting. 1779, 4to., where I have endeavoured to show, from comparative anatomy, that their use is to strengthen the sense of smelling, and that they are not subservient to the formation of the voice. Most of the mammalia, which possess proper horns, have these cavities extending more or less into those processes of the frontal bone, on which the horns are formed: this structure is particularly observable in the *wild goat* (*capra ibex*). They are generally large in the *bisulca*, the *solidungula*, and in most of the carnivorous mammalia. They are absent on the contrary in the seal, in most of the *rodentia*, and the *cetacea*. They receive in the sheep, as is well known, the larvæ of the œstrus ovis; and cases are not very uncommon in which other insects, particularly the *scolopendra electrica*, have accidentally gained admission into them in the human subject, and have caused distressing and tedious symptoms.

§ 246. The anomalous structure of the *elephant*'s proboscis, or trunk, and the blowing-holes of the *cetacea*, must be noticed here, as these parts constitute prolongations and external openings of the nose.

The former organ consists of two canals, separated from each other by an intervening partition. Innumerable muscular fasciculi, running in two directions, occupy the space between these and the integuments. There are fibres of a transverse course, passing like radii from the canals to the in-

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[*] Casp. Bartholin, *loco citato*, fig. 5, 6, of the *hound* (*canis venaticus*).

[†] Stukely, in his *History of the Spleen*, p. 101, tab. 5, fig. 2.

teguments;[*] and others, which run in a more longitudinal direction, but have their extremities turned inwards.[†] The former extend the trunk without causing any contraction of the canals, the latter bend or contract it, and both tend to bestow on it that wonderful mobility which it possesses in every direction.

The blowing hole of the *cetacea* is not a peculiar organ, distinct from the nasal openings, as several naturalists have imagined, but one and the same with these.[‡] It does not, however, seem to be designed for an organ of smelling, but merely to be subservient to respiration, and to the expulsion of the water which enters the mouth with the food.[§]

Cuvier has given a more detailed description of the elephant's trunk in the last vol. of his *Leçons d'Anat. comp.* p. 283—289; and has also represented the part in the 29th plate of the same volume.

The more longitudinal fibres are divided at short intervals by tendinous intersections, which enable the animal to bend any part of the organ, and to give it any requisite degree of curvature. The same structure will confer a power of bending different parts of the trunk in opposite directions; indeed there is no kind of curvature which may not be produced by these longitudinal fibres. These fasciculi occupy the external surface of the organ. The transverse fibres are not all arranged like radii round the canals; but some pass across from right to left, and must therefore affect the diameter of those tubes by their action. The whole of these muscular fasciculi are surrounded and connected together by a white, uniform, adipose substance. The transverse ones are not more than a line in thickness. If the number of these, which appear on a transverse section, be ascertained; and if those portions of the longitudinal fasciculi, which pass from one tendon to another, be reckoned as separate muscles, (for they must have a separate power of action) the whole trunk will contain about thirty or forty thousand muscles, which will account satisfactorily for the wonderful variety of motions which this admirable organ can execute, and for the great power which it is capable of exerting.

The blowing-hole of the whale serves as well for respiration as for the rejection of the water which enters with their food. In consequence of its situation at the top of the head, it is easily elevated beyond the surface of the sea, while the mouth is usually entirely under water.

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[*] *Hist. des Animaux*, tom. iii. tab. 22, fig. 9; Stukely, *loc. cit.* tab. 1, fig. 2.

[†] *Hist. des Animaux*, *loc. cit.* Stukely, tab. 5, fig. 1.

[‡] This has been correctly stated by Tyson, in his *Anatomy of a Porpoise*, tab. 2, fig. 8, 9.

[§] Cuvier, in the *Magazin Encyclopedique*, an 3, tom. ii. p. 299.

The opening in the bones of the head is divided into two by a partition of bone, and is furnished with a valve opening outwards. On the outside of this opening are two membranous bags, lined with a continuation of the integuments, and opening externally. The water which the animal wishes to discharge is thrown into the fauces, as if it were to be swallowed, but its descent into the stomach is prevented by the contraction of the circular fibres of the œsophagus. It therefore elevates the valve placed at the entrance of the blowing-holes, and distends the membranous bag, from which it is forcibly expelled by surrounding muscular fibres.

This apparatus occupies the situation which, in other mammalia, is filled by the nose, which organ, together with the sinuses of the head, the olfactory nerve, &c. is entirely wanting in these animals.

BIRDS.

§ 247. The nostrils open in the several genera of this class in very different parts of the upper mandible; in some, as the *puffin*, (*alca arctica*) the openings are placed at the margins of the bill, and are so small, that they might be easily overlooked. This may serve as an excuse for the erroneous representation of Buffon, that several birds are entirely unprovided with nostrils, and that they smell by means of the palatine openings of the nasal cavity.*

§ 248. Birds have no proper ethmoid bone; their olfactory nerves pass through the orbits to the nose, and are distributed on the pituitary membrane, which covers two or three pairs of bony,† or cartilaginous‡ conchæ narium (*bullæ turbinatæ* or *tubulatæ vesicæ*)§ of various forms and sizes.||

The olfactory nerve of birds comes off from the anterior extremity

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* *Histoire des Oiseaux*, tom. i. p. 13.

† The crane has very large turbinated bones.

‡ This is the case in the toucan (*ramphastos*).

§ They are excellently described under this name by Schneider *De Osse Cribriformi*, p. 180.

|| See Scarpa's representation of the nerves of the nose in the *goose*, *turkey*, and *heron*, *De Auditu et Olfactu*, tab. 3.

of the frontal lobe of the brain, and has, therefore, some analogy with the processus mamillaris of quadrupeds. It passes along a canal to the nose, and is distributed in a very beautiful and distinct manner on the pituitary membrane in many instances, as in the *crane*.

AMPHIBIA.

§ 249. The organ of smelling is less clearly developed in this class of animals. Yet we discover two cartilaginous eminences, which may be compared to the conchæ of warm-blooded animals.*

The origin and course of this nerve are much the same in reptiles as in birds. In the turtle it is a large, strong, and fibrous nerve, and its ramifications in the nose are easily traced.

FISHES.

§ 250. Most of these seem to have double nostrils on each side, for the openings are furnished with a valve-like moveable membrane, which appears like a partition. It was formerly supposed, that this part served also for the organ of hearing in fishes; and this erroneous opinion has been revived even in modern times, but it cannot be necessary to refute such an absurdity now.

§ 251. Behind these openings is generally found, instead of conchæ narium, a very elegantly plaited membrane, disposed in semicircular folds, and having the olfactory nerves distributed on it.†

INSECTS.

§ 252. Numerous facts have long ago proved that several insects can distinguish the odorous properties of bodies even at considerable distances. But the organ in which this sense resides has not hitherto been clearly pointed out.*

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* Scarpa, tab. 5, in a *turtle* and *viper*.

† See representations of this part in the *raia clavata*, by Scarpa, tab. 1, fig. 2; in the *skate*, (*raia batis*) by Harwood, tab. 7; in the *shark*, by Stenonis, in his *Specimen Myologiæ*, tab. 7, fig. 1; in the *squalus catulus*, by Scarpa, tab. 2, fig. 6, 7; in the *frog-fish*, (*lophius piscatorius*) ibid. tab. 1, fig. 3; in the *pike*, by Casserius, *De Auditus Organis*, tab. 12; by Camper, in his *Kleine Schriften*, pt. 2, tab. 2, fig. 1; Scarpa, tab. 2, fig. 1, 2; and Harwood, tab. 5, fig. 4; in the *carp*, ibid. tab. 2, fig. 4, 5.

Since all red-blooded terrestrial animals smell only through the medium of the air, which they take in in inspiration, several naturalists have supposed, that the stigmata of insects are to be considered as organs of smelling.† Others ascribe this office, and with some probability, to the anterior pair of palpi.‡

VERMES.

§ 253. Several animals of this class appear to have the sense of smelling, as many land-snails (*helix pomatia,*§ &c.). But the organ of this sense is hitherto unknown; perhaps it may be the stigma thoracicum.

Some detached remarks on the organ of smelling, in particular fishes, are given by Morgagni in his *Epist. Anat.* p. 350. Padua, 1764, fol.

* Rosenthal, *über den Geruchsinn der Insecten im Archiv. für Physiologie*, p. 427. Ramdohr, *über die Organe des Geruchs der gemeinen Biene*, in the *Mag. der Berlin.* In. Gesell. vol. v. p. 386.

† This was the opinion of S. Reimarus, *uber die Tribe der Thiere*, p. 308, ed. 3rd. See also Dumeril, in the *Magazin Encyclopedique*, an 3, tom. ii. p. 435.

‡ Knoch, in his *Beyträge zur Insectenkunde*, p. 32, tab. 1, fig. 8; and tab. 8, fig. 3, of the *scarabæus frischii*, and *carabus unicolor*.

§ Swammerdam, p. 110.

CHAPTER XX.

ON THE ORGAN OF HEARING.

§ 254. We should naturally expect to find an organ of hearing in most classes of animals,* when we consider the various services which this sense performs; as, that of indicating the approach of danger, of conducting predacious animals to their prey, and of bringing the two sexes together for the purpose of copulation, &c. Red-blooded animals, without any exception, possess this organ. Analogous parts are found in some of the white-blooded; and several others certainly can hear, although the organ of that sense has not been hitherto ascertained.

MAMMALIA.

§ 255. The four-footed mammalia are the only animals which possess true external ears; and, even in that class, several instances occur in which these parts are wanting; particularly among such as live in the water, or under ground.

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* The following works may be consulted for an account of the organ of hearing in the different classes of animals.

Casserius *De Vocis Auditusque Organis.* Ferrara, 1600, fol. (The part relating to the ear is also contained in his *Pentæstheseion.*)

Perrault, *Essais de Physique*, tom. ii.

Geoffroy *sur l'Organe de l'Ouie*, &c. Amsterd. 1788.

Scarpa *De Auditu et Olfactu.*

Comparetti, *Observationes Anatomicæ de Aure interna comparata.* Patav. 1789-4.

Monro's *three Treatises on the Brain, Eye, and Ear.* Edin. 1797-4.

Home, in the *Philos. Trans.* 1800, pt. 1.

Pohl, *Expositio Anatomica Organi auditus per classes Animalium.* Vindebon. 1818.

Weber *De aure et auditu Hominis et Animalium.* Leips. 1820.

They are not met with, for instance, in most of the *seals*, in the *walrus, manati, duck-billed animal,* (*ornithorhynchus*) and *mole.* On the contrary, some have been said to want external ears, who really possess them, as the *marmota* or *mus citillus.* Another error has been committed, in representing the ears of a species of *bat* belonging to this country, (Germany) (*vespertilio auritus*) as double: whereas they are only of an immense size. Still more erroneous is an observation of Haller; that these ears are to be considered as an accidental monstrosity. The essential parts of the external ear agree on the whole with those of the human subject;* but their general form is subject to great variety. In very few, except the *quadrumana,* do they resemble those of man; but this is the case in the *porcupine.* The cartilage is stronger, and more elastic in its structure in the human ear than in that of any other animal, in proportion to its size. In some instances, as in the *opossum,* (*didelphis marsupialis*) the ears are merely membranous.

§ 256. The external auditory passage is furnished with a valve in such animals as go frequently into the water, by which they can close it when they dive. The water-shrew (*sorex fodiens*) affords an example of this structure. The length, breadth, and direction of the meatus vary considerably in the different genera. It is very long and singularly tortuous in the *duck-billed animal.*†

The cetacea are the only mammalia which have not a bony external meatus. The tube is cartilaginous in these animals, and so small that its external orifice will about admit a pin in the dolphin. It arrives at the tympanum after a winding course through the fat, which lies under the skin. It is probable that the sound gains admission to the ear in these animals, rather through the Eustachian tube than through this very narrow meatus externus. That tube opens at the blowing hole, and is furnished with a valve that prevents the admission of the water, which the animal expels through this opening.

§ 257. It is hardly necessary to state, that all mammalia have a *membrana tympani*, a *tympanum* situated within this, and an *Eustachian tube* passing from that cavity to the fauces; except in the *cetacea*, where it opens in the blowing hole. The membrane is rather concave on its outer surface, being slightly depressed in the middle. All the animals of this class are furnished with the two *fenestræ;* the *fenestra ovalis*, which is filled by the base of the stapes; the *fenestra rotunda*, at which the scala tympani of the cochlea commences.

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* The *lobulus* of the external ear however is found in no animal but man.

† Home, in the *Philos. Trans.* 1802, pt. 1, p. 70.

§ 258. In the *horse* and *ass* the Eustachian tube does not open immediately into the larynx; but into a sac peculiar to this class of animals, which is situated on the lateral parts of the lower jaw. These cavities then open by a long fissure, provided with a cartilaginous valve, into the pharynx. Havemann found, in a horse fourteen years old, the cavity of the left side twice its natural size, forming a considerable tumour externally, and containing, besides a good deal of white mucus, 136 cartilaginous concretions, of about the size of a hazel-nut.*

§ 259. In most of the four-footed mammalia, there is connected with the tympanum another cavity; which, according to the situation of the bony organ that contains it, must be compared to the mastoid cells in the temporal bone of man.†

In several animals this organ forms a mere bony cavity, (*bulla ossea*) viz. in the *dog, cat, martin, squirrel, hare,* and some of the *bisulca.* Partial development of this structure is to be seen in the cercopitheci. In the *horned cattle*, on the contrary, and in the *pig*, the cavity is divided into cells by numerous bony plates, which somewhat resemble the divisions in a ripe poppy head.‡

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* Bourgelat, *Elémens de l'Art vétérinaire.* Par. 1769, p. 498.
Rudolphi, *Reisebemerkungen*, vol. i. p. 77, vol. ii. p. 220.
Viborg, *Sammlung von Abhandl. für Thierärzte und Oekonomen*, p. 240.

† Sömmerberg, however, denies that the cavity can be so compared, and considers the bulla ossea a part of the external meatus. See his *Quæstio Physiologica quæ et qualis sit musculorum vis formam osseam mutandi.* Lond. 1801.

‡ Vesalii *Anatomicarum Fallopii Observationum examen.* Venet. 1764, 4to. p. 20.

§ 260. Warm-blooded quadrupeds have, like the human subject, three* *ossicula auditus;* which on the whole resemble in form those of man. But the *ducked-billed animal,* whose structure in every respect is so anomalous, has only two;† and on the contrary, one or two additional small bones are occasionally found, particularly in some *bisulca.*‡

The following is the passage to which the author refers as expressing his opinion on this subject. "Anatomists generally describe a fourth bone (the *lenticulus,* or *os orbiculare*) as intervening between the long leg of the incus and the head of the stapes. Repeated and accurate examinations have convinced me that this part is only an epiphysis of the incus. It is often wanting, even in such ossicula auditus as appear in other respects to be of the most perfect formation; for instance, in those of negroes and North American savages, which I have now before me. When it exists in the adult subject, it can only be separated by the employment of some force; and a microscopical examination of the surfaces shews that the lenticulus has been broken from the incus. Sometimes, indeed, I have found a really separate ossiculum between the incus and stapes; but this cannot, in my opinion, be considered as belonging to the ordinary natural structure, any more than those other supernumerary ossicula, which are found not unfrequently both in man and animals." *Beschreibung der Knochen,* p. 144.

Cuvier describes a portion of bone as passing between the crura of the stapes, from one side of the fenestra ovalis to the other, in the *mole* and *marmot,* (in which last animal it is of considerable size). *Lëçons d'Anat. comp.* p. 489, tom. ii. Mr. Carlisle has represented this part in the *marmot,* and he states its existence likewise in the *guinea pig.* (*Philos. Trans.* 1805, pt. 2.)

Cuvier has also found that the stapes is nearly solid in the *cetacea;* and that there is no perforation in the *walrus.* This peculiarity of structure seems to belong to such mammalia as live in water; for the seal has it in a smaller degree. *Léçons d'Anat. comp.* tom. ii. p.

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* That the *lenticulus,* or fourth bone, is only a process of the incus, I have already shewn in my *Geschicte und Besch. der Knochen des Mensch. Körpers,* p. 155.

See Sir A. Carlisle's excellent paper on the physiology of the stapes, in the *Phil. Trans.* 1805.

† Home, *loco citato.*

‡ Adair, in Cowper's *Myotomia reformata.* Lond. 1694, 8vo. p. 70, fig. 9.

Teichmeyer, *Vindiciæ quorundam Inventorum Anatomicorum.* Jenæ, 1727-4, fig. 5.

505. Carlisle, *loc. citat.* gives drawings of the stapes in these animals.

The second ossiculum of the *ornithorhynchus* approaches very much in its form to the single bone of birds. (Carlisle, *loc. cit.*)

§ 261. The part which is termed the labyrinth of the ear, as far as it has been hitherto investigated in the four-footed mammalia, seems to agree on the whole, in its essential points, with that of the human subject. But the *cochlea* (which belongs indeed exclusively to this class) has in some cases a turn more than in man; not to mention other differences of less importance.*

§ 262. In addition to what has been observed respecting the Eustachian tube of the *cetacea,* some other parts of the organ of hearing exhibit such peculiarity in these animals, and deviate so widely from those of warm-blooded quadrupeds, that they require particular notice.†

Their want of external ear is well known. The opening of the meatus is remarkably small. The bony part of the organ is loosely connected to the skull in the *dolphin* and *porpoise;* and it is completely separate in the *proper whales* (*balænæ*) and *cachalot* (*physeter*).

The hard bony substance, which was formerly very erroneously called *lapis manati* or *tiburonis,* is merely the tympanum and *bulla ossea* of the whale.

The ossicula auditus, and the labyrinth, particularly the bony canals, (*canales semicirculares*) which for this very reason were long overlooked, are remarkably small in the *cetacea.*

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* The reader may consult on this subject the following works, besides those which have been already referred to. Scarpa *De Structura Fenestræ rotundæ Auris.* Mutin. 1777. 8vo. p. 94. P. F. Meckel *De Labyrinthi Auris Contentis.* Argent. 1774.

† On the organ of hearing in the true whale, (*balæna*) see Camper's *Kleine Schriften*, vol. ii. pt. 1. In the *spermaceti whale,* (*physeter*) ibid. vol. i. pt. 2. In the *dolphin,* (*delphinus delphis*) Klein, Hist. Nat. Piscium, pt. 1, p. 29, tab. 5, fig. 1-4, and 7-9. In the porpoise, (*delphinus phocæna*) and *dolphin,* Monro's *Three Treatises,* &c. tab. 5, 6, and his *Physiology of Fishes,* tab. 35.

BIRDS.

§ 263. This whole class,* as well as the following ones, has no cartilaginous external ear, which belongs, therefore, exclusively to the mammalia. This apparent deficiency is compensated in birds, particularly in those of the rapacious kind, by the regular arrangement of the feathers round the opening of the meatus. Several also, chiefly of the last mentioned class, and particularly among the *owls*, have a peculiar valve placed at the opening, partly of a membranous, partly of a muscular structure.†

§ 264. The *membrana tympani* of birds is convex on its outer surface; and the *tympana* of the two ears are connected together by the air-cells of the cranium.‡

They have a single *ossiculum auditus*, connecting the membrana tympani with the fenestra ovalis, and consequently supplying the place of the malleus and stapes of the mammalia.

The part corresponding to the malleus, is generally cartilaginous, and not provided with any *tensor tympani*.

The *Eustachian tubes* have a kind of common opening on the arch of the palate.

§ 265. The *labyrinth* is distinguished by large canals, projecting from the cranium, and not hollowed out of a hard bony substance, as in most mammalia, and by the want of *cochlea*. Instead of the last-mentioned part, birds have a short, obtuse, and hollow bony process, passing obliquely backwards from the vestibulum; and divided by a partition, like the cochlea of mammalia, into two *scalæ*, one of which terminates at the fenestra rotunda. This part receives a portion of the auditory nerve as the cochlea does.

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* On the organ of hearing in this class, see Allen Moulins, in the *Philos. Trans.* vol. xvii. p. 712. Vicq d'Azyr, in the *Mém. de l'Acad. des Sciences*, 1778, p. 381. Scarpa *De Structura Fenestræ rotundæ Auris*, p. 101, and *De Auditu*. Galvani, in the *Commen. Instit. Bonon.* tom. vi. p. 420. Comparetti, tab. 2. Of the *predacious birds*, the *domestic fowl*, and the *sparrow*.

† Klein, *Stemmata Avium*, tab. 10, fig. 2. Comparetti, tab. 2, fig. 2, he compares this part to the concha of the human ear.

‡ Sir E. Home has observed the same kind of communication, by the means of the cells of the cranium, in the elephant.

AMPHIBIA.

§ 266. The different orders and genera of this class* exhibit greater variety in the structure of the organ of hearing than the two former, or the following class. Hence the principal variations must be separately considered.

§ 267. *Turtles, frogs,* and most species of the *lizard* kind, possess, besides semicircular canals, a tympanum and Eustachian tube, like warm-blooded animals. Both the latter parts, however, as well as the ossicula auditus, are wanting in the salamander.

The *membrana tympani* of the *turtle* resembles a mass of cartilage, and is covered externally by the common integuments. Their single *ossiculum* resembles that of birds.

Frogs have a large membrana tympani exposed to view on the surface of the body; a wide opening of their short Eustachian tube at the fauces; two cartilaginous ossicula; and a rudiment in the vestibulum of those soft stony substances, which are found in a more conspicuous form in the *lizards* and *serpents,* and in the three following classes.

The *crocodile* is the only instance in which there is a sort of external meatus in the class amphibia. This animal, as well as the *lizards,* possesses *ossicula,* and the above-mentioned stony concretions in the vestibulum.

The want of tympanum in the *salamander* has been already mentioned. The foramen ovale in this animal is merely closed by a portion of cartilage, and the vestibulum contains a soft stone.

§ 268. The serpents, with a very few exceptions, as the

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* In the 7th vol. of the *Comment. Instit. Bonon.* Brunelli has described and delineated the organ of hearing in the *turtle, tortoise, frog, lizards,* and *serpents.* Comparetti has also exhibited figures of these genera and orders, tab. 2, fig. 13-35; and Scarpa has given most beautiful engravings of the ear in the *turtle, crocodile, green lizard, salamander, viper,* and *blind-worm, De Auditu,* tab. 5. See also Monro, on the *turtle,* in the *Physiology of Fishes.*

blind-worm,* (*anguis fragilis*) have neither tympanum nor Eustachian tube. They have a kind of rudiment of ossiculum.

FISHES.

§ 269. It is only in some genera of cartilaginous fishes, viz. the *skate* and *shark*, and *lampreys*, that a tubular appendix of the vestibulum is continued backwards and outwards, so as to represent a rudiment of a tympanum.

§ 270. Much light has lately been thrown on the organ of hearing in the bony fishes by Professor Weber.† They possess near the anterior cervical vertebræ considerable ossicula, which may be compared to the malleus, incus, and stapes; and in those which are provided with a swimming bladder, these bones are so connected with that organ as to render it probable that it is auxiliary to the sense of hearing.

§ 271. Their internal ear consists of three large canals, which are generally seen to project into the cavity of the cranium.‡ Opposite to the termination of the auditory nerves on the vestibulum, one, two, or three neatly formed stones are found. These are as white as porcelain, particularly in several of the bony fishes, and very dry and brittle in their texture.§

§ 272. The internal ear of fishes is distinguished from that of the other three classes of red-blooded animals, by this remarkable peculiarity, that it grows as the fish increases in size, and consequently that its magnitude is in the direct ratio of the bulk and age of the animal.

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* Scarpa, *loco citato*, p. 26.

† Weber, in the work above cited, p. 28.

‡ See Klein, *Mantissa Ichthyologica*. Lips. 1746, 4to.

Kölreuter, in the *Nov. Comment. Acad. Petrop.* tom. xvii. p. 521. Of the sturgeon and beluga (*acipenser sturio* and *huso*).

Camper's *Kleine Schriften*, vol. i. pt. 2, tab. 2, of the cod; vol. ii. pt. 2, tab. 1-3 of the frog-fish, (*lophius piscatorius*) pike, and skate.

The organ is delineated in several fishes, in the work of Comparetti, tab. 3; in Scarpa, tab. 1, 2, 4; and in Monro's two works. See also J. Hunter's *Observations on the Animal Economy*, p. 69.

§ Klein, *Hist. Piscium*, pt. 1, tab. 2.

The membranous canals and vestibulum of the amphibia and fishes are much smaller than the bony or cartilaginous cavities in which they reside. Hence these parts can be discerned and demonstrated much more easily in these animals than in mammalia and birds, where they are closely surrounded by the bone.

INSECTS.

§ 273. There is no doubt that several insects possess the sense of hearing;* but the organ of this sense is very uncertain. In some of the larger animals of the genus *cancer*, a part can be distinguished, which seems to be analogous to the vestibulum of the former classes.† A small bony tube is found on each side at the root of the palpi: its external opening is closed by a firm membrane; and it contains a membranous lining, on which a nerve, arising from a common branch with that of antennæ, is expanded. The latter circumstance might favour an opinion that the antennæ themselves are organs of hearing; but this is refuted by considering the exquisite sense of hearing which some insects possess which have no true antennæ, as the spiders; and by experiments on others, which shew that the sense of hearing is not weakened by removing the antennæ.‡

VERMES.

§ 274. In the *sepiæ* only has any thing been hitherto discovered at all like an organ of hearing. In the cartilaginous ring, to which the large tentacula of the animal are affixed, two oval cavities appear. In each of these is a small bag, containing a bony substance, and receiving the termination of nerves, like those of the vestibulum in fishes.§

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* See the works of Lehmann and Schelver, which I have already often quoted.

† P. A. Minasi, *Dissertazione sopra varii fatti meno ovvii della Storia Naturale.* Nap. 1775, 8vo. fig. 4, of the *cancer pagurus*. Scarpa, *De Auditu*, tab. 4, fig. 4, 5, 6, of the crawfish. Comparetti, tab. 3, fig. 26, 28, of the several other species. But whether the parts represented in the other figures of this table, on the heads of several insects, as *beetles, butterflies, common flies*, &c. are really organs of hearing, is extremely doubtful.

‡ Lehmann *De Antennis Insectorum*, Dissert. poster. p. 45.

§ Scarpa, *loc. cit.* tab. 4, fig. 7, 11. Comparetti, tab. 3, fig. 10 and 16.

CHAPTER XXI.

ON THE EYE.

§ 275. A SENSIBILITY[*] to the impressions of light is common to all those animals which, in a natural state, are exposed to this element: it appears at least very evidently to exist in some of the most simple *zoophytes,* as the armed polypes (*hydræ*): but the power of perceiving the images of external objects is confined to those who are provided with eyes for the reception of those images. Nature has bestowed on some species, even of red-blooded animals, a kind of rudiment of eyes which have not the power of perceiving light: as if in compliance with some general model for the bodily structure of such animals. This is exemplified in the *proteus*;[†] in the blind rat, (*marmota typhlus*) among mammalia; and in the *myxine glutinosa,* among fishes.

§ 276. Since the eye[‡] is a very complicated organ, particularly in the red-blooded animals, we shall first speak of those peculiarities which affect the globe itself, its membranes, and humours; and afterwards consider the surrounding parts, as the eyelids, lacrymal passages, &c.*

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[*] Much information on the subject of this chapter is to be found in Rudolphi's *Grundriss der Physiologie,* vol. ii. pt. 1. Berlin, 1823.

[†] G. R. Treviranus, in the work above cited, s. 319.

[‡] See Bidloo, *De Oculis et Visu variorum Animalium.* Lugd. Bat. 1715-4.

Zinn *De Differentia Fabricæ Oculi Humani et Brutorum,* in the *Comment. Societ. Reg. Scient. Gotting.* tom. iv. 1754, p. 191; and in the *Comment. Antiquior.* 1778, p. 47.

W. Porterfield *On the Eye.* Edinb. 1759, 2 vols. 8vo.

Haller, in the *Opera Minora,* tom. iii. p. 218.

L. H. T. Schreger's *Versuch einer vergleichenden Anatomie des Auges und der Thränenorgane.* Leipz. 1810.

Schreger's *Ansicht der Augen durch alle Thierclassen,* in the *Abhandlung der Physik. Medicin. Societ. zu Erlangen.*

Large animals have small eye-balls in proportion to their size: this is very remarkably the case with the *whales*. Those which are much under ground have the globe also very small, as the *mole* and *shrew:* in the former of these instances its existence has been altogether denied; and it is not in fact larger than a pin's head.

The eyes of man and the *simiæ* are directed forwards; in the latter animals indeed they are placed nearer to each other than in the human subject. The *lemur tarsius* has them more closely approximated than any other animal. All other mammalia have these organs separated by a considerable interval, and directed laterally. The same circumstance obtains in birds, with the exception of the *owl*, who looks straight forwards. They are placed laterally in all reptiles. Their situation varies much in fishes; they look upwards in the *uranoscopus:* they are both on the same side of the body in the *pleuronectes;* but in general their direction is lateral.

The form of the globe varies according to the medium in which the organ is to be exerted. In man and the mammalia it deviates very little from the spherical figure. In fishes it is flattened on its anterior part; in birds it is remarkably convex in front, the cornea being sometimes absolutely hemispherical. The convexity of the crystalline is in an inverse ratio to that of the cornea. Thus in fishes it is nearly spherical, and projects through the iris, so as to leave little or no room for aqueous humour: the *cetacea*, and those quadrupeds and birds which are much under water, have this part of the same form. The aqueous humour being of the same density with the medium in which these animals are placed, would have no power of refracting rays of light which come through that medium: its place is supplied by an increased sphericity of the lens. In birds these circumstances are reversed; they inhabit generally a somewhat elevated region of the atmosphere; and the rays which pass through this thin medium are refracted by the aqueous humour, which exists in great abundance. Man, and the mammalia which live on the surface of the earth, hold a middle place between these two extremes.

MAMMALIA.

§ 277. It has been long known† that the sclerotica in several quadrupeds of this class, as in the human subject, is not

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[*] A. Blumenthal *De externis oculor. integumentis quorundam Animalium.* Berol. 1812.

[†] Zinn, in the *Comment. Soc. Reg. Scient. Gotting.* tom. iv. p. 192.

throughout of equal strength; but that its posterior is much thicker than its anterior part. It has also been conjectured, that this structure might influence what are called the *internal changes of the eye;* by which the form of the eyeball, consequently the length of its axis, and the respective situation of the lens, are adjusted according to the proximity or remoteness of the object, or in reference to any other relations. I flatter myself that I have ascertained the truth of this conjecture, by discovering the admirable structure of the sclerotica in warm-blooded quadrupeds, which have not only the power of seeing at various distances, but also in two media of such different density, as air and water. In the eye of the Greenland seal, where I first noticed the fact,* the cornea was thin and yielding; the anterior segment of the sclerotica, or that which is immediately behind the latter membrane, was thick and firm; its middle circle thin and flexible; and lastly the posterior part very thick, and almost cartilaginous. (PLATE VI.) The whole eye-ball is surrounded with very strong muscles, and we can easily understand how their action, varied according to circumstances, produces the requisite changes; how the axis of the eye is shortened, when the animal sees in air, by bringing the lens nearer to the back of the globe, in order to obviate the strong refraction which the rays of light experience in passing from the thin medium of air into the thicker one of the eyes, and *vice versâ.*

The sclerotica of the *cetacea* is distinguished by the great thickness of its posterior part; when the eye-ball equals an orange in size, the back of this membrane is an inch thick; so that, although the globe be spherical, the space containing the vitreous humour is of a different form. As the sclerotica approaches to the cornea, it becomes thinner. Its posterior part presents a very singular structure, consisting of very firm tendinous threads and laminæ, most closely interwoven, and of more than cartilaginous hardness* towards the sides.

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* *Comment. Soc. Reg.* vol. vii. an 1784. Dr. Albers has discovered the same circumstances in the eye of the walrus, (*trichecus rosmarus*) and has refuted those objections which have been made to the assigned object of this structure, from the observation of some slight resemblance to it in the eyes of certain land animals, as the horse, &c. See the *Götting. gelerhte Anzeigen der physical. Medicin. Societ. zu Erlangen.* 1803, p. 601.

And especially Sömmering, *De oculor. Hominis Animaliumque sectione horizontali commentatio.* Götting. 1818.

The extent of the cornea, when compared to that of the sclerotica, varies in the different species of mammalia. It seems to be greatest in the porcupine, (*hystrix cristata*) where the cornea extends over half the globe.

§ 278. The choroid coat consists more plainly in the *cetacea* than in any other mammalia, of two distinct laminæ, of which the internal (*membrana Ruyschiana*) is covered with a dull tapetum.

§ 279. The inner surface of the choroid coat possesses, towards the back of the eye, in several genera of this class, particularly in those carnivorous animals which prey by night, and even in the *bisulca*, the most brilliant yellow-green and sapphire-blue colours, forming what is called the *tapetum lucidum*.† The coloured portion of the choroid is only partial, and the rest of the membrane is covered with pigmentum nigrum, as usual.

In consequence of this structure less light will be absorbed; and it must, on the contrary, be reflected from the tapetum against the retina, which lies in front of the membrane.

It is well known that the pigmentum nigrum is entirely, or for the greatest part, deficient in the eye of the *albinos*, which strange variety occurs not unfrequently in the human race, and in several other mammalia and birds. I know, however, no instance of an albino among cold-blooded animals. This anomalous deficiency is always congenital, and is connected with a want of the colouring principle of the skin, and of the hair and feathers. It is hereditary in some mammalia, so as to form a constant breed of white animals, viz. in the *rabbit*, *mouse*, and *horse*, (which latter are those called *glass-eyed*). I cannot believe that any whole species of warm-blooded animals should originally want this pigment, and therefore I consider the ferret (*mustela furo*) to have descended from the polecat (*m. putorius*).*

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* Ruysch, *Thesaur. Anatom.* ii. tab. 1, fig. 1, 2, 6.

Loder, *Tabulæ Anatomicæ*, vol. i. tab. 56, fig. 8.

Albers, in the 1st vol. of the *Abhandlung der physik. medicinisch. Societ. zu Erlangen*, tab. 6.

On the eye of the whale in general, see Albini, *Index Supellectilis*, J. J. Ravii, p. 36 ; also his *Annot. Acad.* lib. vii. p. 40 ; and *Supellex Anatomica*, p. 132.

Musei Gaubiani Pars complectens preparata Anatomica, p. 14.

† Zinn, *loco citato*, p. 196.

H. F. Elsaesser, *De Pigmento Oculi nigro, deque Tapeto.* Tubing. 1800, 8vo.

L. Gmelin, *Indagatio Pigmenti nigri Oculorum Taurinorum.* Götting. 1812.

Mondini, in the *Opuscoli scientifici di Bologna*, tom. ii p. 15.

The tapetum occupies the temporal side of the bottom of the eyeball; i. e. it is placed exteriorly to the entrance of the optic nerve. It exists in the carnivorous and ruminating animals; in the *solipeda*, *pachydermata*, and *cetacea*. In the *dog*, *wolf*, and *badger*, it is of a pure white, bordered by blue.

§ 280. The *retina*† exhibits in some quadrupeds, viz. the *hare* and *rabbit*, very distinct and elegant fibres or striæ of medullary substance, taking for the most part a transverse direction.‡ The remarkable *foramen centrale*, which Sömmering discovered in the human retina, has been since demonstrated in the eyes of several *quadrumana*, where these organs are directed forwards, and have their axes parallel.

I have found it, for instance, very plain in the eye of the common Barbary ape (*simia sylvanus*). The entrance of the optic nerve formed a small *yellow circle* on the retina: near this a larger *grey fold* appeared, with the *foramen centrale* in its middle.

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* I have treated at greater length on the want of this pigment, which is so essential a part in the natural structure of the eye, in the *Comment. Soc. Reg. Scient.* vol. vii. p. 29; and in the third edition of my work, *De Generis Humani Varietate Nativa*, p. 272.

† For many observations on the retina, especially in animals of this country, (Germany) see Wantzel, in Isenflamm's and Rosenmüller's *Beitrogen*, vol. i. p. 157.

‡ Zinn, *loco citat.* tab. 3, fig. 3. Fontana *Sur le Venin de la Vipère*, vol. ii. tab. 5, fig. 12.

In demonstrating this opening in the eye of a *simia cynomolgus,* I advanced the following conjecture as to its use. Man, and such animals as have the two eyes placed with their axes parallel, thereby gain the advantage of seeing objects with both eyes at once, and therefore more acutely. But at the same time they are exposed to this inconvenience, that in a strong light both eyes become dazzled at once; and this happens so much the sooner, because the light falls on the corresponding principal focuses of both eyes at once; the organ not possessing a *membrana nictitans.* This inconvenience seems to be obviated by the *foramen centrale:* since that part which forms the principal focus of the eye opens in a dazzling light, so as to form a kind of small pupil, through which the concentrated rays pass, and fall on the choroid, where they are absorbed by the black pigment.

§ 281. The iris, an organ of very peculiar structure, exhibits in the different genera and species of mammalia more numerous and interesting varieties than any other part of the eye. The colours of its anterior surface, which are peculiar to the different genera, vary in the races and varieties of domestic animals, although less strikingly than in the human subject. These variations are connected, as in the latter instance, with the colour of the hair; so that in spotted dogs, rabbits, &c. a mixture of colours will be seen in the iris.

The substance of the part varies in thickness in the different genera. In no instance have I hitherto been able to discover true muscular fibres; the examination of the part in the *elephant* and *whale* having afforded in this respect the same result, as the tender and almost transparent iris of the *white rabbit.*

In the eye of the *seal* the ciliary vessels are not distributed in the substance of the iris; but lie on its anterior surface, and form a considerable plexus, which is visible without any injection.*

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* *Comment. Soc. Reg. Scient. Goetting. loco citato,* fig. 2, 3.

The pupil in the *bisulca, solidungula, cetacea,* &c. is transverse; in animals of the *cat* kind, particularly in a clear light, it is oblong: not to mention other trivial peculiarities, as the small villous appendix, covered with pigmentum nigrum, which is sometimes seen on the middle of the superior margin of the pupil, particularly in the *horse*. The pigmentum nigrum has a brown colour, in the eye of a white horse which is in my collection; while the other parts of the same eye, which in horses in general are black, have only a slight greyish brown tinge. Swammerdam, in speaking of the remarkable curtain of the pupil, which is found in the *skate,* says he has discovered a similar part in the *horse*. If he does not allude to any unusual formation, but merely to such appendices as I have mentioned, the comparison is certainly too far fetched.*

The figure of the pupil is transversely oblong in the ruminating animals and the horse; it is heart-shaped in the dolphin.

§ 282. The corpus ciliare, and particularly the folds of its internal surface, with their numerous and elegantly arranged blood-vessels, constitutes one of the most wonderful parts of the eye, although its functions, which must undoubtedly be of the highest importance, are hitherto involved in mystery. Its more minute differences in the genera, which have been hitherto examined, are too numerous to be recounted; and they could not be understood without delineations.† Among other instances, those of the *elephant* and *horse* may be mentioned, on account of the remarkable beauty and delicacy of their structure.

§ 283. The size of the *crystalline lens* varies in proportion to that of the *vitreous humour;* and sometimes very considerably. I have found the largest lens in this point of view in the comparatively small eye of the *opossum* (*didelphis marsu-*

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* *Biblia Naturæ,* p. 881.

† Much information may be gained on this subject from Jac. Hovius *De Circulari Humorum Motu in Oculis,* ed. 2. Lugd. Bat. 1716, 8vo. This work, however, is in some parts unintelligible, and not to be depended on; and must, therefore, be consulted with caution.

pialis); the *whale* has the smallest. No mammalia have it so slightly convex on the surface as the adult man. In the *cat, hare,* the *bisulca,* the *horse, opossum,* and *seal,* it becomes more and more convex according to the series in which I have named these animals. Lastly, in the *cetacea* it is nearly spherical.*

The crystalline is smaller in the eye of man than in any animal, and it is largest in the fishes.

The following numbers give the proportions of the three humours, measured on the axis of the eye, after it had been frozen.

	Aqueous Humour.	Crystalline.	Vitreous Humour.
Man	$\frac{5}{22}$	$\frac{4}{22}$	$\frac{15}{22}$
Dog	$\frac{5}{21}$	$\frac{8}{21}$	$\frac{8}{21}$
Cow	$\frac{5}{37}$	$\frac{14}{37}$	$\frac{18}{37}$
Sheep	$\frac{4}{17}$	$\frac{11}{17}$	$\frac{12}{17}$
Horse	$\frac{9}{43}$	$\frac{16}{43}$	$\frac{18}{43}$
Owl	$\frac{8}{27}$	$\frac{11}{27}$	$\frac{8}{27}$
Herring	$\frac{1}{7}$	$\frac{3}{7}$	$\frac{1}{7}$

The greater convexity, which the author ascribes to the seal and whales, arises from their inhabiting the water; so that they require an organ of vision like that of fishes.

It is curious to observe the regularity with which, in some species, the lens divides into certain segments commencing from its centre, in consequence of being dried or immersed in acids.†

§ 284. A *lacrymal gland*‡ exists in all animals of this class. Several quadrupeds have, indeed, an additional one, besides that which is found in the human subject. Some have no

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* F. P. Du Petit, in the *Mém. de l'Acad. des Sciences,* 1730. The memoir is translated in Froriep's *Bibliothek für die vergleichende Anatomie,* vol. i. p. 200.

† Leuwenhoeck, *Arcana Naturæ detecta,* p. 73.

Perrault, *Histoire des Animaux,* pt. 1, tab. 30.

Young, in the *Philos. Trans.* 1793, tab. 20.

Hosack, *Philos. Trans.* 1794, tab. 17.

J. C. Reil, *De Lentis Crystallinæ Structura Fibrosa.* Halle, 1794, 8vo.

‡ Bertin, in the *Mém. de l'Acad. des Sciences,* 1766, p. 281.

puncta lacrymalia; and the elephant has neither *lacrymal bag* nor *os unguis.*[*]

In addition to the lacrymal gland, several mammalia have another body, called the *glandula Harderi.* This is situated nearer to the nose, and pours out a thick whitish fluid near the third eyelid. It joins the proper lacrymal gland in the *hare* and *rabbit;* but is distinguished by its whiter colour. The *ruminantia, carnivora,* and *pachydermata,* have it likewise.

The ducts of the lacrymal gland admit of very easy demonstration in the larger quadrupeds, where they open to the number of sixteen or more, by orifices that will admit a large bristle.

The *hare* and *rabbit* have, instead of puncta lacrymalia, a slit opening into the lacrymal canal.

The *cetacea* want the lacrymal apparatus entirely, as their eyes are preserved in a moist state by the element in which they live.

The muscles of the eye-ball are the same in number in the *simiæ* as in man: but other mammalia possess an additional one, termed the *suspensorius oculi.*

This muscle is of a conical form. Its origin, which takes place from the margin of the optic foramen, represents the apex of the cone; and its insertion into the posterior half of the sclerotica, constitutes the basis. It fills up therefore the interval left between the four recti, and surrounds completely the optic nerve. In several of the *carnivora* and the *cetacea* it is divided into four portions; so that these animals may be said to have eight straight muscles. It must enable the animals which possess it to draw the globe back into the orbit; and hence it has sometimes been called the *retractor* of the eye.

A remarkable peculiarity occurs in the conjunctiva of the zemni, (*mus typhlus*). It is covered with hair as in other parts of the body, so that the eye, which is indeed exceedingly small, seems to be completely useless. A similar structure is also found in two fishes, the murena cecilia and myxine glutinosa (*gastrobranchus cæcus,* Cuvier). *Leçons d'Anat. comp.* tom. ii. p. 394.

§ 285. The nictitating membrane, (*membrana nictitans, palpebra, tertia,* seu *interna, periophthalmium*) of which only a rudiment exists in the *quadrumana* and the human subject, is very large and moveable in some quadrupeds.[†] This is the case in animals of the *cat* kind, in the *opossum,* the *seal,* and particularly in the *elephant.*

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[*] Camper, *Œuvres,* tom. ii. p. 138, where he also states that this animal has no lacrymal gland, nor passage for the tears into the nose.

[†] Tabarrani, in the *Atti di Siena,* tom. iii. p. 115.

§ 286. The relative magnitude of the true eyelids varies considerably in animals of this class. The lower, which is very large in the *elephant*, is very small in the *horse*. In the latter animal, as well as in most quadrupeds, it has no cilia; while in the *quadrumana*, the *elephant*, the *giraffe*, and others, both eyelids possess eyelashes.

BIRDS.

§ 287. The eyes are very large in this class of animals,* and consequently the bony orbits are of great magnitude in proportion to the skull.

In the birds of prey they have a peculiar form, which is similar to that of the chalice, or cup used in the communion service: the cornea, which is very convex, forms the bottom of the cup; and the posterior segment of the sclerotica resembles its cover.†

§ 288. This peculiar form arises from the curvature and length of the bony plates, which, as in all other birds,‡ occupy the front of the sclerotica; lying close together, and overlapping each other. These bony plates form in general a flat, or slightly convex ring; being long and curved in the *accipitres*, they form a concave ring, which gives the whole eyeball the above-mentioned form. Dr. Albers observes that the orbit is very imperfect in birds; and that this bony ring may supply the deficiency.

§ 289. The distinction between certain parts of the eye, where the membranes have been supposed to be continuous, appears more plainly in some birds, than in any other animals.

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* Besides the works which have been referred to above, see the memoirs of Petit on this subject in the *Mém. de l'Acad. des Sciences*, an 1726, 1735, and 1736.
Home in the *Philos. Trans.* 1796.
Albers, *Beyträge*, vol. i. p. 69.
Sömmering, in the *Denkschriften der Akad. zu München*, 1811, p. 177.

† Severini, *Zootomia Democritea*, p. 336.
Em. König, in the *Ephem. Natur. Curios. Dec. II.* an 4, Obs. 34.

‡ Coiter, *Miscell. Observ. Anat. Chirurg.* p. 130.
Pierce Smith, in the *Philos. Trans.* 1795, pt. 2, p. 263.

Thus I have found the boundaries of the choroid coat and iris very clearly defined in the horned owl (*strix bubo*); and those of the margin of the retina, and the posterior border of the ciliary body very distinct in the toucan (*ramphastos tucanus*).

The ciliary processes of birds are not very prominent; they consist rather of striæ than of loose folds. They are always closely connected to the crystalline capsule. There is no tapetum in this class.

The colour of the iris varies in the different species of birds; and in many instances possesses great brilliancy. It has a power of voluntary motion in the parrot.

The retina passes obliquely through the sclerotica, in a sheath of the latter membrane.

§ 290. A great peculiarity in the eye of birds consists in the *marsupium*[*] (*pecten plicatum;* in French, *la bourse, le peigne*) the use of which has not hitherto been very clearly ascertained. It arises in the back of the eye, proceeding apparently through a slit in the retina; it passes obliquely into the vitreous humour, and terminates in that part, reaching in some species to the capsule of the lens. The figure of its circumference is a truncated quadrangle. Numerous blood-vessels run in the folds of membrane which compose it; and the black pigment by which it is covered, suggests an idea that it is chiefly destined for the absorption of the rays of light, when they are too strong or dazzling. Others believe that it serves in this class for the internal changes of the eye; but Crampton has contested this opinion, and described a peculiar circular muscle in the eyeball of the ostrich, and several large birds, by which these changes are effected.[†]

§ 291. Birds have large lacrymal passages which terminate on the surface of the palate.[‡]

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[*] See a neat delineation of the internal parts of the eye in the osprey, (*falco ossifragus*) by D. G. Kieser, *De Anamorphosi Oculi.* Goetting. 1804, 4to. tab. 2, fig. 1. The whole dissertation contains much instructive matter on this subject.

See also J. A. Hegar *De oculi partibus quibusdam.* Götting. 1818.

[†] In Dr. Thomson's *Annals of Philosophy* for March, 1813.

[‡] Monro, *Observations Anatomical and Physiological.* Edinb. 1758, 8vo.

Albers, *loco citato,* fig. 1, 2.

Their nictitating membrane[*] is furnished with two very manifest muscles.[†]

In some species, as the *common fowl*, the *turkey*, *goose*, and *duck*, the lower eyelid, which contains a peculiar small lamina of cartilage, is the most moveable; in others on the contrary, as in the *parrot* and *ostrich*, the upper has the most extensive motion.

Very few birds have cilia in both eyelids; they are found in the ostrich, the *falco serpentarius*, the razor-billed blackbird, (*crotophaga ani*) and in some parrots.

Birds possess both a lacrymal gland and glandula Harderi. The latter is considerably the largest; and is usually placed between the elevator and adductor muscles of the globe. It furnishes a thick yellow fluid, which is poured from a single duct, opening on the inner surface of the third eyelid.

The eyelids are closed in most birds by the elevation of the inferior palpebra, which is the largest. This eyelid has a peculiar depressor muscle arising from the bottom of the orbit. The owl, and the goatsucker are among the few in which the upper eyelid descends.

The third eyelid, or *membrana nictitans*, is a thin, semi-transparent fold of the conjunctiva; which, in the state of rest, lies in the inner corner of the eye, with its loose edge nearly vertical, but can be drawn out so as to cover the whole front of the globe. By this, according to Cuvier, the eagle is enabled to look at the sun.

It is capable of being expanded over the globe of the eye by the combined action of two very singular muscles, which are attached towards the back of the sclerotica. One of these, which is called from its shape the *quadratus*, arises from the upper and back part of the sclerotica; its fibres descend in a parallel course towards the optic nerve, and terminate in a semicircular margin, formed by a tendon of a very singular construction; for it has no insertion, but constitutes a cylindrical canal. The second muscle, which is called the *pyramidalis*, arises from the lower and back part of the sclerotica towards the nose. It gives rise to a long tendinous chord, which runs through the canal of the quadratus, as in a pulley. Having thus arrived at the exterior part of the eyeball, it runs in a cellular sheath of the sclerotica along the under part of the eye, to the lower portion of the loose edge of the *membrana nictitans*, in which it is inserted.

By the united action of these two muscles, the third eyelid will be drawn towards the outer angle of the eye, so as to cover the front of the globe; and its own elasticity will restore it to its former situation.

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[*] It is called by the Emperor Frederic II. *pellicula palpebrarum.*

[†] Petit, in the *Mém. de l'Acad. des Sciences,* 1735 and 1736.

AMPHIBIA.

§ 292. Little is hitherto known concerning the peculiarities in the structure of the eye of this class.[*]

In some reptiles and serpents of this country, (Germany) the common integuments form, instead of eyelids, a kind of firm window, behind which the eyeball has a free motion.

In the green turtle[†] (*testudo mydas*) the sclerotica has a bony ring at its anterior part, composed like that of birds, of thin osseous plates. These animals possess very large lacrymal glands, and a very moveable membrana nictitans; in which circumstance the frog resembles them.[‡]

The ciliary processes are hardly perceptible in the turtle; but they leave an elegant impression on the surface of the vitreous humour. They are distinct and long in the crocodile. The blood-vessels are visible on the surface of the iris; where they form a distinct plexus in the crocodile.

The optic nerve forms a tubercle within the sclerotica; from which the retina commences.

The number, &c. of the eyelids varies considerably in this class. Serpents have none. The turtle and crocodile have three like those of birds. The frog and toad have three; of which the third is much the largest and most moveable.

The turtle has a very large lobulated lacrymal gland. Serpents have nothing of this kind.

FISHES.

§ 293. The peculiarities in the eye of fishes,[§] which belong either to the whole class, or to most of the genera and species, consist in the division of their choroid coat and retina into several manifestly distinct laminæ; and in the existence of two small organs within the eye, which belong exclusively to this class.

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[*] Petit, in the *Mém. de l'Acad. des Sciences,* 1737, p. 142.

[†] Albers, in the *Denkschriften der Akad. zu München,* 1808.

[‡] Caldesi *Osservazioni sulle Testudini,* tab. 8, fig. 11.

[§] Good delineations of the internal structure of the eye of fishes are still wanting. The best which I know of are by Guenellon, of the *cod*'s eye; but they are contained in a book where one should not much expect to find them, viz. in Bayle's *Nouvelles de la Republique des Lettres,* March, 1686, p. 326. See also Albers, in the work above cited; and Rosenthal, in the 10th vol. of the *Archives für Physiologie.*

§ 294. The choroid coat, which in man is a simple membrane, and in some other warm-blooded animals, particularly in the *cetacea*, a double one, consists in fishes of three distinct laminæ. The inner layer forms a *tunica Ruyschiana;* the middle one (*membrana vasculosa* of Haller) is perfectly distinct both from the former and from the exterior coat; which latter must be compared with the proper choroid of all red-blooded animals. Even this last is continued anteriorly into the iris, and possesses in many species the well known brilliant gold and silver colours.

The retina is easily separable into two laminæ; of which the external is medullary, and the internal consists of a fibrous texture.

§ 295. The two other peculiarities belong exclusively to the eye of fishes; and are common at least to the whole bony division of these animals. A body, generally resembling in shape a horse-shoe, lies between the internal and middle layers of the choroid; some have thought it muscular, and others glandular. The tunica Ruyschiana gives origin to a vascular membrane, resembling in its form a bell (*campanula* of Haller). This goes towards the lens, and has, therefore, some resemblance to the marsupium of birds.

No true ciliary body is found, at least in the bony fishes.

§ 296. The crystalline lens of most fishes is very large in comparison with the size of the eyeball, and nearly or entirely spherical. The *vitreous humour* on the contrary is small, and the *aqueous* in many cases is hardly discernible.

§ 297. The following may be enumerated as instances of remarkable peculiarities in the eyes of particular genera and species of fishes. The firm transparent laminæ of common integuments, behind which the eyeballs move, as in some amphibia;[*] the articulation of the globe on a stalk of cartilage in the skate and shark:[†] the curtain (*operculum pupillare*) in the eye of the skate,[‡] which can be let down so as to cover the pupil: and the unique structure of the *lobitis anableps,* where the cornea is divided into two portions, and there is a double pupil with a single lens.[§]

The continuation of the conjunctiva over the cornea admits of being demonstrated in the eel. For it comes off sometimes with the rest of the skin of the head in stripping off the integuments of this animal.

The organ of vision exists only in one class of animals, without exception, viz. in birds. In mammalia there are two instances of complete blindness, one in the *blind mouse* (*spalax typhlus,* Pall. *Mus typhlus,* L.) and the other in the *golden mole* (*chrysochlorus, sorex aureus*). Among amphibia the *proteus anguinus* has small eyes covered over with a transparent membrane, through which it has merely the powers of perceiving light, without being able accurately to distinguish objects. Among fishes the *hag-fish* (*gastrobranchus cæcus myxine glutinosa,* Linn.) is said to have no trace of the organ of vision, and in the *blind murena* no traces of the eye can be seen externally, but beneath the skin rudiments of this organ may be detected. Among insects there are several species of *beetles* which live in the nests of ants, and are nourished by them, that have no eyes; further there is a species *braula,* very nearly allied to the dipterous insect, and which live parasitically on *bees,* in which no eyes have been detected. There are also some species of *ants,* as the *formica contracta* and *formica cæca,* in which the organ of vision is wanting. In Linnæus's class *vermes,* the *cephalopoda* are provided with eyes; the existence of the organ of vision is also ascribed to the *gasteropoda,* which Rudolphi, however, is disposed to doubt. In *snails* the eyes are placed at the extremities of the tentacula. In the remaining mollusca the eyes are certainly wanting.

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[*] *Abbildungen natur-historisch. Gegenstände,* pt. 6, where the part is represented in the *ostracion bicuspis.*

[†] Stenonis *Specimen Elementor. Myologiæ,* tab. 5, fig. 1.

Goyeau, in the *Mercure de France,* Dec. 1757, p. 130.

Perrault, *Essais de Physique,* tom. iii. tab. 1, fig. 4.

Radkin, in Abel's *Journey in the Interior of China,* p. 338.

[‡] Stenonis *De Musculis et Glandulis,* p. 68. Camper, in the *Mémoires présentés à l'Acad. des Sciences de Paris,* tom. vi. tab. 3, fig. 1.

[§] Seba *Thesaur. Rer. Natural.* tom. iii. tab. 34.

Camper, in the German translation of Monro's *Physiol. of Fishes,* p. 165.

Lacepede, in the *Mém. de l'Institut. National,* tom. ii. p. 372.

Schneider, in the 4th vol. of the *Neue Schriften der Naturf. Gesells. zu Berlin.*

The muscles of the membrana nictitans were supposed to exist only in the *elephant* among mammalia, but Rudolphi has discovered them in the *hyæna,* and Albers has seen them in the *seal.* These parts have been described in several mammalia by Rosenthal in his *Diss. de externis Oculorum tegumentis.* Berol. 1812.

In animals which have a third eye-lid, there is a peculiar gland, which has been incorrectly stated to exist in the human subject. The matter which it secretes is of a yellowish white colour, and thick consistence.

All mammalia, and even fishes, possess the four straight and two oblique muscles of the eye. In the *tortoise* and *crocodile* there are, in addition to these six muscles, small posterior straight ones. In *frogs* and *toads* there are three additional recti. Birds have only the six usual muscles. Man and the apes have only six, but the rest of the mammalia have, in addition to the anterior, four posterior straight muscles, or the retractor muscle, as it is called, which in the predacious and cetaceous animals, divides into four portions. Where these posterior muscles exist, the eye can be drawn back with great force. In birds and amphibia the muscles of the eye, and consequently its motions, are very weak. In the *ray* and *shark* the motions of the eye are much increased by this organ resting on a thin cartilaginous pulley which is attached to the bottom of the orbit. In the other fishes the mobility of the eye is slight, and the motions confined.

The form of the eye frequently varies in different animals. If the axis of the eyes of animals of different sizes were compared with their diameter, they will be sometimes found equal. This is the case according to Sömmering, in the *lynx*, the *racoon*, *ostrich*, *falco chrysäetos*, *strix bubo*, and the *coluber æsculapii;* and, according to Treviranus, in the *fox*, *badger*, *hedgehog*, and the *falco buteo.* In man the axis is somewhat longer than the diameter, according to Sömmering, as 1 : 0,95. In the *simia inuus,* as 1 : 0,99 ; in the *bat* this proportion is the most striking, viz. as 1 : 0,91. In all the other animals of which Sömmering and Treviranus took the measurements, the diameter has been found larger than the axis. In the *whale* it is by far the largest. The proportion of the axis to the diameter in the eye of the *balæna mysticetus* is, according to Sömmering, as 1 : 1,43 ; according to Treviranus, as 1 : 1,54. In order to obtain any thing like an average, a great number of measurements must be taken of eyes as fresh as they can be obtained.

Attention should be paid to the proportion of the cornea to the sclerotica, as on this the form of the eye very much depends. In cetaceous animals and fishes the cornea is quite flat, on the contrary it is very convex in night birds of prey.

In mammalia the cornea is connected, with very few exceptions, in the same way as in the human subject. There are, however, some modifications. The sclerotic is of different degrees of thickness in different parts ; its anterior and posterior portions are thick in the *ox* and *horse*, and particularly the *seal*, whilst the central one is thin. In the cetaceous animals the sclerotic increases in thickness from before to behind; in the *whale* it is sometimes more than an inch in thickness. Also in birds the sclerotic becomes thicker at its posterior portion.

The iris, which presents great varieties of colour in the mammalia, and which is for the most part dark coloured in wild animals, is remarkable in birds for the diversity and beauty of its hues. In the *amphibia*, and still more in *fishes*, it has a shining metallic hue, resembling silver or gold. Rudolphi has not besn able to detect muscular fibres in the irides of any animals.

The pupil is round in the *quadrumana*, and in some carnivorous animals; in the *hyæna* and the *cat* genus, it is perpendicular; in the *ruminantia*, *solidungula*, *multungula*, and *cetacea*, it is horizontally situated. In the *horse* genus, and several of the *ruminantia*, the iris is furnished on both edges, or at least on the inferior one, with small round processes strongly tinged with pigment. In *birds* the pupil, without exception, appears to be round; and also in *tortoises* and *lizards*, as the *lacerta viridis, agilis*, &c. In *crocodiles* and *serpents*, it is vertical. The pupil of fishes is round; and in the *ray* it is provided with a peculiar process coming from its upper edge, by which it is capable of being closed.

The ciliary processes are developed in *mammalia*, *birds*, and some of the *amphibia*. Cuvier has not been able to detect them in the common *lizards*, or in *serpents*. They exist also in the *shark*, and though Cuvier denies their existence in all bony fishes, they are very visible in the *tunny*, and Treviranus has observed them in the *sturgeon* and the *salmon*. In the *cephalopoda* they are deeply imbedded in a kind of sulcus in the lens.

The three humours of the eye exist, without exception, in all the vertebrated animals; the aqueous humour exists in a very minute quantity in *fishes*, while it is most abundant in birds. The crystalline lens is spherical in *fishes*, and approximates more or less to this form in all aquatic animals, as the *crocodile*, the *cetacea*, the *seal*, *water-rat*, and in aquatic birds. The few serpents which go into the water, as the *coluber natrix*, have also a spherical lens. In the *chameleon* the lens approximates to a spherical form; in land birds, on the contrary, it is flat. The vitreous humour is, according to Tiedemann, of very slight consistence in *birds;* but to this remark there are many exceptions. It exists in small quantity in all animals; fishes, however, possess most of it.

INSECTS.

§ 298. Two kinds of eyes, very dissimilar in their structure, are found in this class.* One sort is small and simple (*stemmata*);

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* M. de Serres *Sur les Yeux composés et les Yeux lisses des Insectes.* Montpell. 1813.

the others, which are large, seem to consist of an aggregation of smaller eyes;[*] for their general convexity is divided into an immense number of small hexagonal convex surfaces, which may be considered as so many distinct corneæ. The first kind is formed in different numbers in most of the *aptera*, as also in the larvæ of many winged insects. When these undergo the last or complete metamorphosis, and receive their wings, they gain at the same time the large compound eyes. Several genera of winged insects, and *aptera* (as the largest species of *monoculi*[†]) have stemmata besides their compound eyes.

§ 299. The internal structure has hitherto been investigated only in the large polyedrous eyes.[‡] The back of the cornea (which is the part, divided in front into the hexagonal surfaces, called in French, *facettes*) is covered with a dark pigment. Behind this are numerous white bodies, of a hexagonal prismatic shape, and equal in number to that of the facettes of the cornea. A second coloured membrane covers these, and appears to receive the expansion of the optic nerve.

§ 300. Further investigation is, however, required in order to shew how these eyes enable the insect to see; and to determine the distinctions between two such very different organs.

I have given, on a former occasion, the reasons which led me to think it probable, in opposition to the general opinion formerly maintained; that the polyedrous eyes are adapted for distant objects, and the simple ones for such as are more near. This is confirmed by observing, that butterflies, which in their perfect or winged state, have the large compound eyes, have only the myopic organs while larvæ.

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[*] Hooke's *Micrographia Restaurata*, tab. 20, 21.

[†] Andre, in the *Philos. Trans.* vol. lxxii. part 2, of the *Monoculus Polyphemus.* M. de Serres, in the *Journal de Physique*, 1809.

[‡] Swammerdam, tab. 20, has represented the structure of the eye in the drone or male bee.

Cuvier, in the *Mem. de la Société d'Hist. Nat. de Paris*, an 7, p. 41, fig. 3, that of the *dragon-fly*, (*libellula grandis*).

Yet there are still some doubts respecting the uses of these two kind of eyes; for some complete *animalia subterranea,* as the *gryllus gryllotalpa,* have both kinds.

VERMES.

§ 301. The *cuttle-fish* only, of this whole class,* has been hitherto shewn to possess true eyes; the nature of which cannot be disputed. They resemble on the whole those of red-blooded animals, particularly fishes; they are at least incomparably more like them than the eyes of any known insects; yet they are distinguished by several extraordinary peculiarities.† The front of the eye-ball is covered with loose membranes instead of a cornea; the iris is composed of a firm substance, which seems like a continuation of the sclerotica; and a process projects from the upper margin of the pupil, which gives that membrane a semilunar form.

The corpus ciliare is very completely formed.

In all other vermes the eyes are entirely wanting, or their existence is very doubtful. Whether the black points, at the extremities of what are called the horns of the common snail,‡ are organs which really possess the power of vision, is still problematical.§

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* Carus *Lehrbuch der Zootomie,* p. 67, tab. 4, fig. 2, 9.

† Swammerdam, tab. 52, fig. 2.

‡ Ibid. tab. 4, fig. 7, 8.

§ Meckel's Archiv. vol. v. p. 206.

J. Lauchs, in his *Naturgeschicte der Ackerschneche.* Neuemb. 1820, p. 20.

CHAPTER XXII.

ON THE MUSCLES.

§ 302. The heart and other muscular viscera have been already treated of. We have only to speak here of the proper muscles, which are destined to the performance of the voluntary motions. As the details of myology do not come within the plan of this work, the present chapter will include only a few remarks on the peculiarities in the muscular structure of the different classes, and of some particularly remarkable species.*

MAMMALIA.

§ 303. The degree of resemblance between the muscles of the mammalia† and those of the human subject‡ may be infer-

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* It can be hardly necessary for me to state, that the first vol. of Cuvier's excellent work contains by far the most complete account that we hitherto possess of comparative myology in general: numerous remarks on the subject may be found also in Borelli *De Motu Animalium*; and in Barthez, *Nouvelle Mechanique des Mouvemens de l'Homme et des Animaux*. Carcassone, 1798, 4to.

Many striking points in the myology of man, and some of the higher animals, are admirably explained and illustrated in a treatise, entitled 'Animal Mechanics,' which has been recently published by the Society for the Diffusion of Useful Knowledge, and which is understood to be the production of Mr. Charles Bell.

† We have excellent accounts of the myology of particular species of this class: as for instance, of the *chimpansé*, (*simia troglodytes*) by Tyson; of the *dog*, by Douglas, in his *Specimen Myographiæ comparatæ*; and by Garengeot, in the *Myotomie Humaine et Canine*. Paris, 1724, 8vo.; of the *horse*, by Stubbs, in his excellent *Anatomy of the Horse*. Lond. 1766; and Alton's *Naturgeschicte des Pferdes*. Weim. 1816; of the *cow*, by Vitet, *Médecine Vétérinaire*, vol. i.

‡ On the muscles of the face in man, as they serve to express the different passions, see C. Bell, *On the Anatomy of Expression in Painting*, p. 94.

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red, in any particular instance, by comparing the skeleton of the animal with that of man. The similarity is greatest, on the whole, in the *quadrumana*.[*] Yet these are distinguished by the smallness of their buttock and calf of the leg; the strength and convexity of which parts constitute peculiar beauties in the human form.[†]

The differences which we discern in the muscles of the lower extremity between man and the other mammalia, arise out of that characteristic feature, which so strikingly distinguishes man from all other animals, viz. his erect stature. An accurate examination of this subject will shew us that the erect position belongs to man only; and that the well known passage of the Roman poet is not merely distinguished by the elegance of its diction, but confirmed by the results of physiological investigation.

> Pronaque cum spectent animalia cetera terram,
> Os homini sublime dedit; cœlumque tueri
> Jussit; et erectos ad sidera tollere vultus.

In order to enable any animal to preserve the erect position, the following conditions are required: 1st, that the parts of the body should be so disposed as to admit of being maintained with ease in a state of equilibrium; 2ndly, that the muscles should have sufficient power to correct the deviations from this state; 3rdly, that the centre of gravity of the whole body should fall within the space occupied by the feet; and lastly, that the feet themselves should have a broad surface, resting firmly on the ground, and should admit of being in a manner fixed to the earth. All these circumstances are united in the necessary degree in man only.

The broader the surface included by the feet, the more securely will the line of gravity rest within that surface. The feet of man are much broader than those of any animal, and admit of being separated more widely from each other. The sources of the latter prerogative reside in the superior breadth of the human pelvis, and in the length and obliquity of the neck of the femur, which by throwing the body of the bone outwards, disengage it from the hip-joint.

The whole tarsus, metatarsus, and toes, rest on the ground in the human subject, but not in other animals. The simiæ, and the bear,

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See also Landseer's *Engravings of Lions, Tigers, Panthers, and Leopards*. Lond. 1823; a work distinguished by the beauty of its execution, and exhibiting most striking illustrations of *character* and *expression* in the nobler carnivorous animals.

[*] Lordat *Sur l'Anatomie du Singe Vert*. p. 42.

[†] Aristotle *De Partibus Animalium*, 4, 10.

have the end of the os calcis raised from the surface; while on the contrary it projects in man, and its prominent portion has a most important share in supporting the back of the foot. The exterior margin of the foot rests chiefly on the ground in the simiæ; which circumstance leaves them a freer use of their thumb and long toes in seizing the branches of trees, &c.; and renders the organ so much the less adapted to support the body on level ground.

The *plantaris* muscle, instead of terminating in the os calcis, expands into the plantar fascia in the simiæ: and in other quadrupeds it holds the place of the *flexor brevis*, or *perforatus digitorum pedis*, passing over the os calcis in such a direction that its tendon would be compressed, and its action impeded, if the heel rested on the ground.

The extensors of the ankle joint, and chiefly those which form the calf of the leg, are very small in the mammalia, even in the genus simia. The peculiar mode of progression of the human subject sufficiently accounts for their vastly superior magnitude in man. By elevating the os calcis they raise the whole body in the act of progression; and by extending the leg on the foot, they counteract that tendency which the weight of the body has to bend the leg in standing.

The thigh is placed in the same line with the trunk in man; it always forms an angle with the spine in animals; and this is often even an acute one. The extensors of the knee are much stronger in the human subject than in other mammalia, as their double effect of extending the leg on the thigh, and of bringing the thigh forwards on the leg forms a very essential part in the human mode of progression.

The flexors of the knee are, on the contrary, stronger in animals; and are inserted so much lower down in the tibia (even in the simiæ), than in the human subject, that the support of the body on the hind legs must be very insecure; as the thigh and leg form an angle, instead of continuing in a straight line.

The *gluteus maximus*, which is the largest muscle of the human body, is so small and insignificant in animals, that it may almost be said not to exist. This muscle, which forms the great bulk of the human buttock, extends the pelvis on the thighs in standing; and, assisted by the other two *glutei*, maintains that part in a state of equilibrium on the lower extremity, which rests on the ground, while the other is carried forwards, in progression. The true office of these important muscles does not therefore consist, as it is usually represented, in the common anatomical works, in moving the thigh on the pelvis, but in that of fixing the pelvis on the thighs, and of maintaining it in the erect position.

Such then are the supports by which the trunk of the human body is firmly maintained in the erect position. The properties of the trunk, which contribute to the same end, do not so immediately belong to the present part of the work; but may be slightly mentioned, to complete the view of the subject. The breadth of the human pelvis affords a firm basis on which all the superior parts rest securely; the same part is so narrow in other animals, that the trunk represents an inverted pyramid; and there must consequently be great difficulty in maintaining it in a state of equilibrium, if it were possible for the animal to assume the erect position. In those instances, where the pelvis is broader, the other conditions of the upright stature are absent; the bear, however, forms an exception to this observation, and consequently admits of being taught to stand and walk erect, although the posture is manifestly inconvenient and irksome to the animal.

The perpendicular position of the vertebral column under the centre of the basis cranii, and the direction of the eyes and mouth forwards, would be as inconvenient to man, if he went on all-fours, as they are well adapted to his erect stature. In the former case he would not be able to look before him; and the great weight of the head, with the comparative weakness of the extensor muscles, and the want of ligamentum nuchæ, would render the elevation of that organ almost impossible.

When quadrupeds endeavour to support themselves on the hind extremities, as, for instance, for the purpose of seizing any objects with the fore feet, they rather sit down than assume the erect position. For they rest on the thighs as well as on the feet, and this can only be done where the fore part of the body is small, as in the *simiæ*, the *squirrel*, &c.; in other cases, the animal is obliged also to support itself by the fore feet, as in the *dog*, *cat*, &c. The large and strong tail, in some instances, forms as it were a third foot, and thereby increases the surface for supporting the body; as in the *kangaroo* and the *jerboa*.

Various gradations may be observed in the mammalia, connecting man to those animals which are strictly quadrupeds. The simiæ, which are by no means calculated for the erect position, are not, on the other hand, destined like the proper quadrupeds to go on all fours. They live in trees, where their front and hinder extremities are both employed in climbing, &c.

The true quadrupeds have the front of the trunk supported by the anterior extremities, which are consequently much larger and stronger than in man; as the hind feet of the same animals yield in these respects to those of the human subject. The chest is in a manner suspended between the scapulæ; and the *serrati magni* muscles, which support it in this position, are consequently of great bulk and strength. When viewed together they represent a kind of girth surrounding the chest.

§ 304. Of the muscles which do not exist in man, nor as far as we hitherto know, in the *quadrumana*, but which on the contrary are found at least in the greatest number of quadrupeds; the cutaneous expansion of the trunk (*panniculus car-*

nosus, expansio cornea, musculus subcutaneus), and the *suspensorius oculi,*[*] deserve particular mention.

The *panniculus carnosus* does not exist in the *pig*; but is of extraordinary strength in such animals as have the power of rolling themselves up; as the *tatu,* (*armadillo*) *manis, porcupine, hedgehog,* &c.[†]

The tendinous fibres of this cutaneous expansion may be split into threads of a hundred feet or more in length in the *cetacea*; and the inhabitants of the Aleutian islands prepare in this way a very delicate kind of thread.

§ 305. Among such, on the contrary, as are found only in particular genera and species, the most remarkable are the extremely numerous muscles of the prehensile tails of some *cercopitheci* (*sapajous,* belonging to the *simiæ* of Linnæus), and other South American and Australasian mammalia;[‡] those which we have already described in the trunk of the *elephant*;[§] and that which belongs to the epiglottis of several mammalia (*cerato-epiglottidæus*).[||]

§ 306. Other muscles, which are common to most orders of the class, are distinguished in some species by remarkable strength, which adapts them for peculiar kinds of motion. This is the case with the *gluteus medius*[¶] of the horse; which in connexion with some others, particularly the *gemellus,*[**]

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[*] Zinn, in *Comment. Soc. Reg. Scient.* Gotting. tom. i. p. 48.

[†] See the excellent monograph of Himly, *über die Zusammenkugeln des Igels.* Brunswick, 1801, 4to.

[‡] Mery reckoned no less than 280 muscles in the prehensile tail of a *cercopithecus.* Du Hamel, *Hist. Acad. Reg. Scient.* p. 276.

[§] See the interesting observations of Cuvier on the organization of the elephant's trunk, in the seventh part of the *Menagerie du Museum National.* He intends to explain the wonderful structure of this completely unique organ in a separate work, with twelve plates. Some remarks on the subject may be found in the valuable *Description anatomique d'un Elephant male, par* P. Camper, *publiée par son fils,* A. G. Camper. Paris, 1802, folio.

[||] J. G. Runge *De Voce ejusque Organis.* Lugd. Bat. 1753, 4to.

[¶] Stubbs's *Muscles,* tab. 2, q, r, s, t; and tab. 3, a, b, c, d.

[**] Ibid. tab. 3, 60-64.

enables the animal to kick out backwards with such astonishing force; with the immensely long flexors of the beaver's tail, or the extensors of the *kangaroo*, &c.

The *pectoralis major*, *latissimus dorsi*, and *teres major*, are of vast size in the mole; and enable the animal to dig its way under ground, and to throw up the earth.

BIRDS.

§ 307. The muscles in this class are distinguished by possessing a comparatively weak, irritable power, which is soon lost after death; and by their tendons becoming ossified, as the animal grows old, particularly in the extremities, but sometimes also in the trunk. I have observed this to a very remarkable degree in the *crane*.

This appearance led several physiologists of the seventeenth century to the erroneous conclusion, that the bones in general, at least for the most part, are formed from tendons.*

§ 308. The most remarkable circumstances in the myology of this class† have been incidentally mentioned in previous parts of this work. For instance, muscles which are not exclusively peculiar to birds, but are more commonly found in them than in the mammalia, as those of the membrana nictitans;‡ or such as are deficient, as the diaphragm; or distinguished by their remarkable size and peculiar form, as the pectoral muscles.

Birds possess three pectoral muscles, arising chiefly from their enormous sternum, and acting on the head of the humerus. The first, or *great pectoral*, weighs, of itself, more than all the other muscles of the bird together. The keel of the sternum, the fork, and the last ribs, give origin to it; and it is inserted in a rough projecting line of the humerus. By depressing that bone, it produces the strong and violent motions of the wing, which carry the body forwards in flying. The *middle pectoral* lies under this; and sends its tendon over the junction of the fork, with the clavicle and scapula, as in a pulley, to be inserted in the upper part of the humerus; which bone it elevates. By this contrivance of the pulley, the elevator of the wing is placed at the under surface of the body. The third, or *lesser* pectoral muscle, has the same effect with the great pectoral, in depressing the wing.

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* See Stenonis *De Musculis et Glandulis*, p. 26. Casp. Bartholin *Specimen Historiæ Anatomicæ Partium Corporis Humani*, p. 185.

† On the myology of birds the reader may consult Stenonis, in the *Act. Hafniens.* 1673, p. 6; and Valentini, *Amphitheat. Zootom.* pt. 2, p. 8.

Also Vicq d'Azyr, in the *Mém. de l'Acad. des Sciences de Paris*, 1772. Merrem's *Vermischte Abh. aus der Thiergesch.* p. 144.

And Wiedemann's *Archives*, vol. ii. p. 68.

‡ These muscles are described in the chapter which treats on the eye.

One of the flexor tendons of the toes of birds (produced from a muscle which comes from the pubis) runs in front of the knee; and all these tendons go behind the heel; hence the flexion of the knee and heel produces mechanically a bent state of the toes, which may be seen in the dead bird; and it is by means of this structure that the bird is supported, when roosting, without any muscular action.

This circumstance of the flexion of the toes accompanying that of the other joints of the lower extremity of birds, was long ago observed by Borelli, and attributed by him to the connexion which the flexors of the toes have with the upper parts of the limb, by which they are mechanically stretched when the knee is bent. This explanation has been controverted by Vicq d'Azyr and others, who have referred the effect to the irritability of the muscles. The opinion of Borelli appears, notwithstanding, to be well founded; for not only the tendon of the accessory flexor passing round the knee, but the course of the flexor tendons over the heel, and along the metatarsus, must necessarily cause the contraction of the toes, when either of these joints is bent; and if the phenomenon was not produced on mechanical principles, it would be impossible for birds to exhibit it during sleep, which they do, or to prove the effect on the limb of a dead bird, than which nothing is more easy. The utility of this contrivance is great in all birds, but particularly so in the rapacious tribe, which by this means grasp their prey in the very act of pouncing on it; and it is still more necessary to those birds which perch or roost during their sleep, as they could not otherwise preserve their position, when all their voluntary powers are suspended. Rees's *Cyclopedia*, art. Birds.

AMPHIBIA.

§ 309. The two chief divisions of this class are distinguished from each other by a remarkable difference in their muscular structure, which arises from a corresponding diversity in the skeleton. In the reptiles, for instance, and particularly in the *turtles** and *frogs*, where the trunk of the skeleton possesses but little mobility, the muscles are very few in number. Not only the diaphragm, but also the muscles of the abdomen and chest are wanting in the genus *testudo*. The other muscles are, however, of vast strength in this genus. In the *serpents*, on the contrary, they are more uniform and thin, and more numerous, beyond all comparison, in consequence of the vast number of vertebræ and ribs, and the want of all external organs of motion.

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* For the myology of the *testudo tabulata* see Wiedemann's *Archives*, vol. iii. pt. 2, p. 78.

FISHES.

§ 310. The muscles of this class[*] are distinguished from those of animals which breathe by means of lungs, not only by receiving a smaller supply of blood, and consequently being of a paler colour, but also by their disposition in layers, and by the uniformity[†] of their substance, which in general is destitute of tendinous fibres. This structure, together with the number and bulk of their muscles, is well calculated to support that great expenditure of strength and exertion, which is a necessary consequence of the peculiar abode, and whole economy of these animals.[‡]

INSECTS.

§ 311. The observations which have just been made concerning the uniformity, number, and strength of the muscles of fishes will hold equally good, on the whole, of insects; but under other modifications, and generally in a more striking degree.[§] In the few which have been hitherto investigated with a view to this subject, some differences have been observed. The immensely strong muscles of the claw in the *crab* and *lobster*,[||] bear considerable analogy to those in some

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[*] Lacepede, *Hist. Naturelle des Poissons*, tom. i. *Discours*, p. 47.

Sir A. Carlisle, *On the Arrangement and Mechanical Action of the Muscles of Fishes* in the *Phil. Trans.* 1806.

[†] Kielmeyer, *über die Verhältnisse der Organischen Kräfte untereinander*, p. 22, 8vo. 1793, Stutgard.

[‡] Dr. Blane's *Lecture on Muscular Motion*, p. 54.

[§] Kielmeyer, *loco citato.*

[||] Stenonis *Specimen Elementorum Myologiæ*, p. 55.

Perrault,

organs of red-blooded animals; while the muscles of other insects, as may be seen in the larvæ, are distinguished by a peculiar bluish white colour, and flattened form. Their great number concurs also with these characters in distinguishing them from those of the former classes. Lyonet* reckoned 4,061 in the larva of the *cossus*,† and 2,186 of these belong to the alimentary canal.

VERMES.

§ 312. The arrangement of the muscular system of the *mollusca*‡ has considerable analogy, on the whole, to that of the larvæ of insects. Those which inhabit shells have, moreover, peculiar muscles connecting them to their testaceous covering, and enabling them to move it. Thus the *snail* has large muscular fasciculi running along the abdomen, attaching it to the upper turn of the shell, and enabling the animal to withdraw itself into the cavity. The *bivalves* have powerful adductor muscles to close their shells.§ In several of the *mollusca nuda* there is a considerable apparatus of cutaneous fibres, by which a very remarkable shortening of the body can be produced. A similar and very astonishing contractile power resides in the gelatinous parenchyma of the *zoophytes*, and animals which inhabit corals, in whose structure nothing like muscular fibres can be distinguished.

Perrault, *Essais de Physique*, tom. iii. tab. 4, fig. 3.

And especially F. Succow, *Specimen Myologiæ Insectorum de astaco Fluviatili.* Heidelb. 1813.

[*] Tab. 6, 7, 8, 15, 16, 17; and tab. 5, fig. 7, 8.

[†] This number includes about ten times as many as belong to the human body.

[‡] See an account of the muscles of the *aphrodite aculeata*, in Pallas's *Miscellanea Zoologica*, tab. 7, fig. 13.

Of the *tritonia aplysia*, &c. by Cuvier, in the *Annales du Muséum National d'Hist. Nat.* tom. i. and ii.

Of the snail, (*helix pomatia*) by Swammerdam, tab. 6, fig. 2; of numerous bivalves and multivalves in several figures of Poli's work.

[§] Hunter, *On the Blood*, p. 111. Poli, vol. i. *Introduction*, p. 59.

THE GENERATIVE FUNCTIONS.

THE GENERATIVE FUNCTIONS.

CHAPTER XXIII.

ON THE MALE ORGANS OF GENERATION.

§ 313. In considering the comparative anatomy of the sexual functions, we must confine ourselves to those animals which possess male organs, destined for the purpose of impregnation, and female parts for that of conception.

To the former belong chiefly the testes, vesiculæ seminales, prostate and penis. Yet the three last mentioned parts, and particularly the vesiculæ and prostate, are by no means constantly found even in red-blooded animals.

The following general view of the subject of generation, in the 5th volume of *Leçons d'Anatomie comparée*, affords a comparative statement of the manner in which that function is executed in the different classes.

The nature of *generation*, which is the greatest mystery in the economy of living bodies, is still involved in impenetrable obscurity. The *creation* of a living body, that is, its formation by the union of particles suddenly brought together, has not hitherto been proved by any direct observation. The comparison of this process to that of crystallization is founded in a false analogy: crystals are formed of similar particles attracting each other indifferently, and agglutinated by their surfaces, which determine the order of their arrangement: living bodies, on the contrary, consist of numerous fibres or laminæ of heterogeneous composition, and various figures, each of which has its peculiar situation in relation to the other fibres and laminæ. Moreover, from the instant in which a living body can be said to exist, however small it may be, it possesses all its parts; it does not grow by the addition of any new laminæ, but by the uniform or irregular development of parts which existed before any sensible growth.

The only circumstance common to all generation, and consequently the only essential part of the process, is, that every living body is attached at first to a larger body of the same species with itself. It constitutes a part of this larger body, and derives nourishment for a certain time from its juices. The subsequent separation constitutes *birth;* and may be the simple result of the life of the larger body, and of the consequent development of the smaller, without the addition of any occasional action.

Thus the essence of *generation* consists in the appearance of a small organized body in or upon some part of a larger one, from which it is separated at a certain period, in order to assume an independent existence.

All the processes and organs which co-operate in the business of generation in certain classes, are only accessory to this primary function.

When the function is thus reduced to its most simple state, it constitutes the *gemmiparous,* or *generation by shoots.* In this way the buds of trees are developed into branches, from which other trees may be formed. The polypes (*hydra*) and the sea anemones (*actinia*) multiply in this manner; some worms are propagated by a division of their body, and must therefore be arranged in the same division. This mode of generation requires no distinction of sex, no copulation, nor any particular organ.

Other modes of generation are accomplished in appropriate organs; the germs appear in a definite situation in the body, and the assistance of certain operations is required for their further development. These operations constitute *fecundation,* and suppose the existence of *sexual parts;* which may either be separate or united in the same individual.

The office of the male sex is that of furnishing the *fecundating* or *seminal fluid;* but the manner in which that contributes to the development of the germ is not yet settled by physiologists. Some, forming their opinions from the human subject and the mammalia, where the germs are imperceptible before fecundation, suppose that these are created by the mixture of the male fluid with that which they suppose to exist in the female; or that they pre-exist in the male semen, and that the female only furnishes them with an abode. Others consult the analogy of the other classes of animals and of plants. In several instances, particularly in the frog, the *germ* may be clearly recognized in the *ovum* before fecundation; its preexistence may be concluded in other cases, from the manner in which it is connected to the ovum when it first becomes visible; for it is agreed on all sides that the ovum exists in the female before fecundation, since virgin hens lay eggs, &c. From such considerations these physiologists conclude that the germ pre-exists in all females; and that the fecundating liquor is a stimulus which bestows on it an independent life, by awakening it, in a manner, from the species of lethargy in which it would otherwise have constantly remained.

The origin of the germs, and the mode of their existence in the female; whether they are formed anew by the action of life, or are pre-existent, and inclosed within each other; or whether they are disseminated, and require a concourse of circumstances to bring them into a situation favourable for their development, are questions which, in the present state of our knowledge, it is utterly impossible for us to decide. These points have for a long time been agitated by physiologists, but the discussion seems now to be abandoned by universal consent.

The combination of the sexes and the mode of fecundation are subject to great variety. In some instances they are united in the same individual, and the animal impregnates itself. The *acephalous mollusca* and the *echinus* exemplify this structure. In others, although the sexes are united in each individual, an act of copulation is required, in which they both fecundate and are fecundated. This is the case with the *gasteropodous mollusca* and several *worms*. In the remainder of the animal kingdom the sexes belong to different individuals.

The fecundating liquor is always applied upon, or about the germs. In many cases the ova are laid before they are touched by the semen; as in some fishes of the bony division, and the *cephalopodous mollusca*. Here, therefore, impregnation is effected out of the body; as it is also in the *frog* and *toad*. But in the latter instances the male embraces the female, and discharges his semen in proportion as she voids the eggs. In most animals the seminal liquor is introduced into the body of the female, and the ova are fecundated before they are discharged. This is the case in the *mammalia*, *birds*, most *reptiles*, and some *fishes*; in the *hermaphrodite gasteropodous mollusca*, in the *crustacea*, and *insects*. The act by which this is accomplished is termed *copulation*.

In all the last mentioned orders ova may be discharged without previous copulation, as in the preceding ones. But they receive no further development, nor can they be fecundated when thus voided.

The effect of a single copulation varies in its degree; it usually fecundates one generation only; but sometimes, as in poultry, several eggs are fecundated; still, however, they only form one generation.

In a very few instances one act of copulation fecundates several generations, which can propagate their species without the aid of the male. In the plant-louse (*aphis*) this has been repeated eight times; and in some *monoculi* twelve or fifteen times.

When the germ is detached from the ovary, its mode of existence may be more or less complete. In most animals it is connected, by means of vessels, to an organized mass, the absorption of which nourishes and developes it until the period of its birth. It derives nothing, therefore, from the body of the mother, from which it is separated by coverings varying in number and solidity. The germ, together with its mass of nourishment, and the surrounding membranes, constitutes an egg, or *ovum;* and the animals which produce their young in this state are denominated *oviparous.*

In most of these the germ contained in the egg is not developed until that part has quitted the body of the mother, or has been *laid;* whether it be necessary that it should be afterwards fecundated, as in many fishes; or require only the application of artificial heat for its incubation, as in birds; or that the natural heat of the climate is sufficient, as in reptiles, insects, &c. These are strictly *oviparous* animals.

The ovum, after being fecundated, and detached from the ovarium, remains in some animals within the body of the mother, until the contained germ be developed and hatched. These are *false viviparous* animals, or *ovo-viviparous.* The *viper*, and some *fishes* afford instances of this process.

Mammalia alone are truly viviparous animals. Their germ possesses no provision of nourishment, but grows by what it derives from the juices of the mother. For this purpose it is attached to the internal surface of the uterus, and sometimes, by accident, to other parts, by a kind of root, or infinite ramification of vessels, called a *placenta.* It is not, therefore, completely separated from the mother by its coverings. It does not come into the world until it can enjoy an independent organic existence. The mammalia cannot, therefore, be said to possess an *ovum* in the sense which we have assigned to that term.

From the above view of the subject, generation may be said to consist of four functions, differing in their importance, and in the number of animals to which they belong.

1st, The *production of the germ,* which is a constant circumstance; 2ndly, *fecundation,* which belongs only to the sexual generation; 3dly, *copulation,* which is confined to those sexual generations, in which fecundation is accomplished within the body.

Lastly, *uterogestation,* which belongs exclusively to viviparous generation. Cuvier, *Leçons d'Anat. comparée*, tom. v.

§ 314. The testes, and sometimes the vesiculæ seminales and prostate, vary most remarkably in their magnitude in such animals as have a regular rutting season.* They are very diminutive at other periods of the year, but swell at that particular time to a comparatively vast magnitude. This change is particularly observable in the testes of the *mole, sparrow,* and *frog.*[*]

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* See Dr. Jenner *On the Migration of Birds,* in the *Phil. Trans.* 1823.

§ 315. It is necessary to mention here, in a cursory and general manner, the peculiar organs possessed by the males of some species, for the purpose of holding the female during the act of copulation. Of this kind are the spur on the hind feet of the male *ornithorhynchus;*[†] the rough black tubercle, formed in the spring season on the thumb of the common *frog;* the two members, formed of bones articulated to each other, near the genitals of the male *torpedo* and other *cartilaginous fishes;* the forceps on the abdomen of the male *dragon-fly,* &c. Ray, Klein, Battara, and others, considered these parts as real organs of generation; and the same mistake was committed by Menz and Krüger concerning the tubercles on the thumb of the frog. Equally erroneous is the opinion of Tyson, that the sternum of the *cyclopterus lumpus* (*lump-sucker*) serves the male to retain the female in its embrace in the act of impregnation; an opinion which that physiologist entertained, from an idea that such an organ would be peculiarly useful to the animal, on account of the shortness of its penis. To say nothing of the situation of the sternum on the neck, together with the convexity of the abdomen being calculated rather to impede than to assist the act of copulation, and also of the existence of this organ in both the male and female, it has escaped the notice of that otherwise excellent physiologist that these fishes do not copulate. The female deposits the ova alone at the spawning season, as is the case with many other species of fishes, and the deposited ova are afterwards fructified by the male.

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[*] In animals, which have lost the testes by the operation of castration, a similar circumstance may be observed in some of the remaining organs; as in the vesiculæ seminales of the gelding. Bourgelat, *Elémens de l'Art Vétérinaire.* Par. 1769, 8vo. p. 359.

[†] The spur of the *ornithorhynchus* not only enables the animal to retain the female in a firm position, but probably acts as a specific stimulant during the act of copulation. On the subject of this peculiar organ see Rudolphi, in the *Abhandl. der Berliner.* Wispersch, 1820.

Seifert, *Spicilegia Adenologica,* p. 8, tab. 1, fig. 5.

Meckel's *Archiv.* vol. viii.

MAMMALIA.

§ 316. A *scrotum,* or bag, in which the testes hang on the outside of the abdominal cavity exists only in the mammalia; but is not by any means common to all the genera. It is not found, and that for very obvious reasons, in the aquatic animals of this class; nor in the perfect *subterranea* (those which live under ground,) as the *mole;* nor in such as roll themselves up on the approach of danger, as the *hedgehog.* These, which may be called true *testiconda,* (i. e. animals having their testes concealed) must be distinguished from such as have the power of withdrawing these glands from the abdomen, and retracting them into the cavity according to circumstances; as the *guinea-pig,** the *squirrel,* the *rat,* the hamster,† (*marmota cricetus*) and Canadian musk-rat‡ (*mus zibethicus*).

In those *testiconda* which have the penis much concealed by the integuments in its unerected state, as the *hare, cat,* &c. it is difficult sometimes to distinguish the sexes on the first view, particularly at an early age.

A scrotum exists in all the *quadrumana* and in most of the *carnivora;* in animals of the *opossum* kind, which have it in front of the pelvis; in the *hare* and *gerboa ;* in most of the *ruminating* genera, and in the *solidungula.*

The testes are placed under the skin of the perineum in the *pachydermata* and the *civet;* or under that of the groin, as in the *camel* and *otter.* They pass from the abdomen into one or the other of these situations, particularly at the rutting season, in the *bats,* the *mole, shrew,* and *hedgehog*; and in several *rodentia,* as the *rat, guinea-pig, porcupine, beaver, squirrel,* &c. They remain constantly in the abdomen in the *ornithorhynchus paradoxus* and *hystrix,* in the *elephant, hyrax,* the amphibious mammalia, and the *cetacea.*

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* Freuler, *Monographia caviæ porcelli Zoologica.* Gotting. 1820, p. 54.

† Sulzer, pp. 38, 67.

‡ Sarrazin, in the *Mém. de l'Acad. des Sciences de Paris,* 1725.

Seiler *De testiculorum ex abdomine in scrotum descensu.* Lips. 1817, p. 33, tab. 2, fig. 1.

The *tunica vaginalis* exists constantly in the mammalia. As the horizontal position of the body obviates the danger of herniæ, the cavity of this covering always communicates by means of a narrow canal with the abdomen, in such animals as have the testes remaining constantly in the scrotum. Where these glands occasionally pass out of the abdomen and return again, the communication is very broad and free.

§ 317. In several quadrupeds, as the *dog, horse, ram*, and others, there is a body composed of condensed cellular substance, lying according to the axis of the testicle near the epididymis, and known by the name of *corpus Highmori.* This is not a canal, nor does it possess that artificial structure which has been described and delineated by several anatomists of the seventeenth century.*

The seminal tubes are collected in some animals into large fasciculi; as in the *baboons*, most of the large *carnivora*, the *wild boar*, and the *rhinoceros.* It is the union of the septa which divide these fasciculi, that constitutes the corpus Highmori. In most of the *rodentia*, and particularly in the *rat*, these tubes are large and parallel, and very easily separable.

The vasa deferentia are usually enlarged in size, and assume a cellular structure for some short distance previous to their termination. The structure of this part is the most remarkable in the *horse;* where "the vas deferens, in passing over the bladder, enlarges to the size of the human thumb; this amplification extends from its entrance into the urethra to the distance of five or six inches from that point, where it again becomes of its ordinary diameter.

"The inside of this enlargement is composed of cells, and somewhat resembles in construction the cells of the corpus cavernosum penis, passing in a transverse direction across the tube. In the centre of this enlargement passes the small canal of the vas deferens; each cell communicates by one, two, or more small pores with the canal of the vas deferens, and the cells diminish as they approach the neck of the bladder, till they are lost in a smooth passage entering the urethra.

"What the purpose of this structure is, does not appear; it must retard the passage of the semen, and probably adds some fluid to it, secreted from the cells themselves." Mr. Clark in Rees's *Cyclopedia*, art. Anatomy of the Horse.

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* De Graaf *De Viror. Organis Generat. inservient.* tab. 3, fig. 4, in the *dog.*

See also the excellent delineations by A. Monro, junior, *De Testibus.* Edinb. 1755, 8vo. tab. 4, fig. 5, in the *dog;* fig. 8, in the *horse;* tab. 3, fig. 5, in the *pig,* &c.

The cells of this part contain a thick white fluid, which flows out in abundance on compression.

An analogous structure is met with in the *ram*.

§ 318. Most species of mammalia, and, with the exception of the *cetacea*, some out of every other order in the class possess *vesiculæ seminales*. Mr. Hunter, at least, expressly asserts that these parts are not found in the *cetacea*.* I am indeed aware of the common opinion, which supposes the first discovery of these important parts to have been made in the *dolphin*, by that excellent zootomist Rondelet, to whose labours the science is so much indebted. But the passage quoted for this purpose from his classical work† seems to me to be quite as inadequate to prove that point, as the observation of Ray on the male organs of the *porpoise*,‡ which has also been applied by Haller to the vesiculæ seminales. The vesiculæ seminales swell to a vast size in the rutting season in many animals, as in some of the *simiæ*, and most particularly in the *hedgehog*.§

Among the species in which these parts do not exist, are the *dog* and *cat kind*, the *bears*, the *opossums*, *sea-otters*, *seals*, and the *ornithorhynchus*.

The following animals have no vesiculæ seminales, according to Cuvier: the plantigrada, except the racoon and hedgehog; all the carnivora and marsupial animals; the ruminantia, the seals, the cetacea, and the two species of ornithorhynchus. Their existence or absence does not seem to follow any general law.

Their form and structure vary almost infinitely in the different mammalia, where they often terminate in the urethra by a separate opening from that of the vas deferens. This circumstance, together with the fact of their containing generally a fluid of different appearance and properties from those of the semen, and the glandular structure which their coats possess in many instances, militates strongly against the opinion which considers these vesicles as reservoirs of the semen, and inclines us to suppose with Mr. Hunter, that they add a peculiar secretion of their own to the fluid which comes from the testes.

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* *Philos. Trans.* vol. lxxvii. p. 442.

† *Piscibus Marinis*, p. 461.

‡ *Philos. Trans.* vol. vi.

§ Wetter, *Anatome erinacei Europæi*. Götting. 1818, p. 61, tab. 3, fig. 1, 2.

See Mr. Hunter's remarks on the vesiculæ seminales, in his *Observations on certain Parts of the Animal Economy*, p. 27 et seq.

In the hedgehog these parts are of a vast size, much exceeding the volume of the testes. They form four or five bodies on each side, consisting of a small and infinitely convoluted tube, and open separately into the urethra. The rodentia are generally distinguished by the great size of their vesicles. These parts in the guinea-pig are long, uniform, cylindrical cavities, containing generally a firm cheesy matter. In the boar they are very large, and of a lobulated structure; a common excretory duct receives the branches from the lobes. In the horse they form two large and simple membranous bags, opening near the vasa deferentia, but separately.

§ 319. The possession of a prostate (in some instances simple, but generally divided into two parts) is peculiar to the mammalia, and seems to take place in every species of the whole class. In many animals at least, where its existence has been denied, as in the *goat* and *ram*, considerable glandular bodies are found, which bear a greater resemblance to the prostate than to Cowper's glands.*

§ 320. In many species the penis consists of a single *corpus cavernosum*, without any septum. The *pig* and the *cetacea* furnish examples of this structure; and in the latter animals there are numerous tendinous layers crossing it.†

In some species, where the act of copulation requires a longer portion of time, as in the *dog*, *badger*, &c. the corpus spongiosum of the glans, and of the posterior part of the penis, swells during the act much more considerably than the rest of the organ, and thus the male and female are held together during a sufficient space of time for the discharge of the seminal fluid.‡

It has been doubted whether the swelling of the *corpus spongiosum* in *dogs* does not frequently occasion a protracted and painful adhesion long after the purposes of coition are completed, but Blumenbach's explanation coincides with that of the Roman poet and physiologist.

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* Haller, in *Comment. Soc. Reg. Scient.* Gotting. tom. i. tab. 1.

† Ruysch, *Epist. Problemat.* 15, tab. 19, fig. 5.

‡ Daubenton, tom. v. tab. 47; and Walter, *Mémoire sur le Blaireau*, in the *Mém. de l'Acad. de Berlin*, 1792, p. 20.

> " In triviis non sæpe canes discedere aventes,
> Divorsi cupidè summis ex viribu' tendunt,
> Cum interea validis Veneris compagibus hærent?
> Quod facerent nunquam nisi mutua gaudia nossent."
>
> *Lucret.* lib. iv.

In the quadrumana and bats the penis hangs loose from the pubis as in man. In most of the other mammalia it is contained in a sheath of the integuments, which extends nearly to the navel. This sheath has an adductor and a retractor muscle. The penis is generally folded when drawn within the sheath, on account of its length. In some animals it turns back when it has reached the front of the pubis, and passes out near the anus; this is the case with the guinea-pig, marmot, and squirrel. It goes directly backwards from the beginning in the hare, rat, dormouse, and opossum, where the prepuce is found close to the anus.

The corpora cavernosa form a cylindrical ring in the kangaroo, and the urethra passes in the centre.

Mr. B. Clark has given us the following interesting observations on the penis of the horse, in his description of the anatomy of that animal in the 2nd vol. of Rees's *Cyclopædia*, art. Anatomy of the Horse.

" We have remarked that the penis of the horse possesses a voluntary power of erection, not known to the human, nor perhaps to most other animals. This power is exerted on making water, and though the erection is not very considerable, it is yet sufficient to bring the penis from its sheath, which is effected apparently by its increased gravity, from blood accumulating in the cavernous cells of this part. After staling this semi-erection of the penis subsides, and it is again retracted within the sheath. This operation, though occurring daily to the sight of every one, has not, it is apprehended, been noticed by any veterinary writer.

" The urethra of the horse is muscular from one extremity to the other, being formed on the outside of strong transverse fleshy fibres, and supported by a strong ligament.

" In the glans of the penis, immediately over the opening of the urethra, externally, there is a large cell or cavity, smooth on the inside, and lined with a membrane which secretes a brown unctuous substance for the lubrication of the penis, and defending it from the corrosive effects of the urine; another cell of a similar description with the former is observable on the side of the urethra, and nearly surrounding it; it is separated from the former by a membranous partition.

" The apparently unctuous secretion above described is miscible with water; it burns, however, in the fire like an oily substance, and is not soluble in spirits of wine or nitrous acid, nor does it dry on exposure to the air during several weeks.

"There is nothing resembling a frenum to the penis of the horse.

"The cavernous body has no longitudinal septum.

"Another singularity in the genital parts of this animal is, that there is an immense congeries of veins, lying on the back of the penis, which are filled during copulation, forming an elevation nearly as large as the penis itself; these veins communicate with both the cavernous and spongious bodies."

§ 321. Several species of mammalia, both among those which possess no vesiculæ seminales, and thereby require a longer time for completing the act of copulation, and those which are not distinguished by this peculiarity, possess a peculiar bone in the penis, generally of a cylindrical form, but sometimes grooved. This is the case with some of the *simiæ*, most of the *bat-kind*, the *hamster*, and several others of the *mouse-kind*, the *dog*, *bear*, *badger*, *weasel*, *seal*, *walrus*, &c. A *simia cynomolgus*, which I lately dissected, had a small *os penis*, with large vesiculæ seminales. Delineations of this bone in several species of animals may be seen in Redi,[*] and in the works of Meyer and Daubenton. It is somewhat remarkable that this bone should not be found in all the species of the same genus. Thus it is wanting in several *simiæ*, in some *bats*, and in the *hyena* of the dog-kind.[†]

§ 322. In most of the male animals of this class the urethra runs on to the end of the glans, and forms a common passage for the urine, prostatic liquor, and semen. In some few species, the passage which conducts the two former fluids, is distinct from that of the seminal liquor. The bifid fork-like glans of the *opossum*[‡] has three openings, one at the point of bifurcation for transmitting the urine; and two for the seminal fluid at the two extremities of the glans. The short urethra of the *ornithorhynchus paradoxus* opens directly into the cloaca, and the large penis of the animal serves merely to conduct the seminal fluid. It divides into two parts at its extremity, and each of these is furnished with sharp papillæ, which are perforated for the passage of the semen.* A similar structure obtains in the *ornithorhynchus hystrix,* where the penis divides into four *glandes.*†

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[*] *De Viventibus intra Viventia*, tab. 26.

[†] See J. F. Hermann, *Observat. ex Osteol. comparat.* Argent. 1792, p. 13.

[‡] Cowper, in the *Philos. Trans.* vol. xxiv. p. 1583, fig. 2-5. Among other peculiarities of this singular animal it may be mentioned, that the penis lies behind the scrotum.

§ 323. In some species of the cat-kind the glans is covered with retroverted papillæ, which, as these animals have no vesiculæ seminales, may enable the male to hold the female longer in his embraces. In a collection at Hanover there is a penis which must have belonged to a tiger, or some similar species; where the lower part of the glans is furnished with two strong horny processes divided each into three points, which are turned backwards. Similar horny processes are found in the penis of the *savia paca.*

§ 324. Lastly, it deserves to be mentioned, that in some species of this class, the male penis, while unerected, is turned backwards, so that the urine is voided in the male in the same direction as in the female. The *hare, lion,* and *camel,* afford instances of this structure. But the statement which has been so often repeated since the time of Aristotle,‡ that these *retromingentia* copulate backwards, is erroneous.

BIRDS.

§ 325. The testes, which lie near the kidneys, and the *ductus deferentes,* are the only male organs which are constantly found in the whole class.§

In a very few instances, as in the *cock,* the last mentioned canals terminate in a dilated part, which has been considered analogous to the vesiculæ seminales. Instead of a penis, most birds have in the cloaca two small papillæ, on which the seminal ducts terminate. This is the case in the *cock, turkey,* and *pigeon.*

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* Home, in the *Philos. Trans.* 1802, tab. 4, fig. 1.

† Ibid. tab. 12, fig. 1.

‡ *Historia Animalium,* II. 1, V. 2; and *De Partibus Animal.* IV. 10.

§ G. G. Tannenberg, *Spicilegium Observationum circa Partes Genitales Masculas Avium.* Goetting. 1789-4.

Some few species have a simple penis of considerable length, which is ordinarily concealed and retracted within the cloaca; but remains visible externally for some time after copulation. It forms a long worm-shaped tube in the *drake,** and constitutes a groove in the *ostrich,* which is visible when the animal discharges its urine.†

The testes of birds consist of a congeries of seminal tubes analogous to those of the mammalia.

AMPHIBIA.

§ 326. The kidney, testes, and epididymis, lie close together in the *testudines,* but each of the three organs may be distinguished, by its peculiar colour and structure, on the first view. They appear to have no vesiculæ seminales ;‡ I could at least discover none in a *testudo græca* which I lately dissected. The penis, on the contrary, is very large, and retracted within the cloaca in its ordinary state. Instead of an urethra, this part contains a groove, whose margins approach to each other, when the part is erected, so as to form a closed canal. This may be compared with the groove-like continuation of the œsophagus, which goes into the third stomach of ruminating animals. The glans terminates in an obtuse hook-like point, somewhat resembling the end of the elephant's trunk.

§ 327. *Frogs*§ have large vesiculæ seminales, and a small papilla in the cloaca instead of a penis. Both these parts are wanting in the *toad.*[*]

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* De Graaf *De Mulierum Organis,* tab. 17. Tannenberg, tab. 1 and 2. Ibid. tab. 2 and 3 ; also Home, *loc. citat.* tab. 12, fig. 2.

† Cuvier, in the first part of the *Ménagerie du Museum National.*

‡ I should not express myself with uncertainty on this subject, if Lieberkuhn had not ascribed vesiculæ seminales to the turtle, (he does not mention the species) G. E. Hamberger, *Physiol. Med.* p. 712.

There is much obscurity in the different descriptions of the male organs of generation of the turtle and tortoise. The various observations on this subject are collected by Schneider, in his *Natural History of the Genus Testudo,* p. 129. See also Gilibert, *Médecin Naturaliste,* 1st series. Lyons, 1800-8, p. 290 ; and Bojanus, in the work above cited.

§ Rösel, tab. 5, fig. 1, 2, and 3, tab. 6, fig. 1.

§ 328. *Crocodiles* have a simple penis, while the *lizards* of this country (Germany) have two; and the *water-newt,* which does not copulate, has no organ of the kind.

§ 329. *Serpents* have long slender testicles, no vesiculæ seminales, but a double penis, each of which has a bifid point covered with sharp papillæ.[†]

FISHES.

330. The male organs of generation possess very different structures[‡] in the different orders of this class. We shall take two species as examples, the *torpedo* for the cartilaginous, and the *carp* for the bony fishes.

In the former instance there are manifest testicles, consisting partly of innumerable glandular and granular bodies, and partly of a substance like the soft roe of bony fishes. We find also *vasa deferentia,* and a vesicula seminalis, which opens into the rectum by means of a small papilla.[§]

The soft roe supplies the place of testes in the carp,[||] and most other bony fishes. It forms two elongated flat viscera of a white colour, and irregular tuberculated surface: placed at the sides of the intestines and swimming-bladder, so that the left encloses the rectum in a kind of groove. Through the middle of each soft roe passes a *ductus deferens,* which opens behind into a kind of vesicula seminalis, and this terminates in the cloaca. It is a curious circumstance that hermaphrodites, possessing the complete organs of both sexes, are found very frequently in this species; much oftener than among other fishes.*

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[*] Ibid. tab. 21, fig. 25 and 26.

[†] Tyson, in the *Philos. Trans.* vol. xiii. tab. 1, fig. 2, in the *rattlesnake,* and fig. 3, in the *viper.*

Franque *De Serpentium quorundam Genitalibus.* Tubing. 1817.

[‡] Ph. Cavolini *über die Erzeugung der Fische und der Krebse mit Anmerkungen von* A. W. Zimmermann. Berlin, 1792, 8vo. in German.

De Graaf, *Partium Genitalium Defensio,* p. 253.

[§] Lorenzini, tab. 4, fig. 4. See also Monro's *Physiology of Fishes,* tab. 11, 12.

[||] Petit, in the *Mém. de l'Acad. des Sc.* 1733, tab. 17.

I possess the whole viscera of two such individuals, which were found some years ago within a short time of each other.

INSECTS.

§ 331. The animals† of this class exhibit such numerous varieties of structure in the different orders, genera, and species,‡ that we shall be contented with choosing two of the latter as examples. These are, the moth of the silk-worm, (*bombyx mori*) which is chosen because its genital organs resemble those of some of the more perfect red-blooded animals; and a species of locust (*gryllus*) on account of the external resemblance between the male and female organs.

In the latter (*gryllus verrucivorus*) the large testicles, with their convoluted fasciculi of vessels, bear a very close resemblance to the ovaries, in which the ova are collected into similar bundles.§

In the moth of the silk-worm we distinguish, besides the testes, long *vasa deferentia*, even a kind of vesiculæ seminales, and a very considerable penis, with a hook-shaped glans.‖

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* See Alischer, in the *Breslau Collections*, 14 vers. p. 645. Schawlbe, in the *Commerc. Lit. Noric.* 1734, p. 305; and Morand, in the *Hist. de l'Acad. des Sc.* 1737, p. 51.

† See Henrich Schaeffer *De generatione Insectorum, partibusque ei inservientibus.* Ratisb. 1821.

‡ See a representation of these parts in the *scarabæus nasicornis*, by Swammerdam, tab. 30; in a large water-beetle, tab. 22; in the *nepa cinerea*, tab. 3; in the *papilio urticæ*, tab. 36; in the *ephemera horaria*, tab. 14; in the drone, tab. 21 and 22; in the *musca cameleon*, tab. 42; in the *musca putris*, 43.

In a *cicada*, Malpighi *De Bombyce*, tab. 11, fig. 2.

In a *crab*, Cavolini, tab. 2, fig. 10, 11. In the *cancer Bernhardus*, Swammerdam, tab. 11. In the *crawfish*, Rösel, vol. iii. tab. 60.

§ Rösel, vol. ii. tab. 9, of the *locusts*.

‖ Malpighi, tab. 10, fig. 1. Swammerdam, tab. 28, fig. 3.

VERMES.

§ 332. From this class we shall select two instances.[*] The one is an intestinal worm, (*ascaris lumbricoides*) and derives therefore some interest from its connexion with nosology. The *cuttle-fish*, of the class mollusca, forms the other, and is selected on account of the remarkable peculiarities in its male organs.

The ascaris has one testis, occupying nearly the middle of the animal's body, and consisting of a single vessel convoluted into a long bundle, but admitting of being unravelled with facility, when it appears to be about three feet in length. Towards the posterior part of the worm it forms a larger tube, which nearly equals a crow's quill in size, and becomes connected to the penis, which lies concealed near the tail, and is probably projected at the time of copulation.[†]

Dr. Hooper states that he has never found any distinction of sex in these worms, but that they all possess the parts described as belonging to the female.

See the account compiled by him in the *Mem. of the Lond. Med. Soc.* vol. v. p. 237. Yet Dr. Baillie has given a figure of the male worm, similar to that of Tyson, but it is copied from Werner. *Fascic.* 4, pl. 9, fig. 2 and 4. The representation of Cuvier agrees with that of Dr. Hooper. *Leçons d'Anat. comp.* tom. v. p. 187.

The male organs of the *cuttle-fish* (*sepia loligo*) have excited particular attention, from the remarkable, and indeed somewhat heightened description which Turberville Needham[‡] gave of them, and which formed the basis of Buffon's theory of generation.[§]

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[*] For the male organs of such vermes as have the generative parts of both sexes combined in each individual, see Swammerdam, tab. 8, fig. 9, where they are represented in the *slug*.

For those of the *aplysiæ*, *clio borealis*, and *tritonia*. See Cuvier, *loco citato*.

Of the *lepas balanus*, Poli, vol. i. tab. 4, fig. 13.

Of the *helix pomatia*, Swammerdam, tab. 5, fig. 10.

[†] Tyson, in the *Philos. Trans.* vol. xiii. p. 161, fig. 1.

[‡] *Nouvelles Observations Microscopiques*, tab. 3 and 4.

[§] *Histoire Naturelle*, tom. ii. p. 230.

The part which corresponds to the soft roe of bony fishes, contains at the spawning season several hundred small tubular seminal receptacles (about four lines in length); these are placed in bundles towards the vas deferens, and are contained in a thick fluid. These tubes are expelled from the body in an entire state, when a spiral vessel, which they contain, together with the semen, as in a sheath, bursts their thin anterior extremity, from which the semen escapes and impregnates the spawn of the female.

CHAPTER XXIV.

ON THE FEMALE ORGANS OF GENERATION.

§ 333. An ovarium is the most essential and universal of all the female parts of generation. In addition to this, those animals which breathe by means of lungs, as well as some fishes, and several white-blooded animals, have also *oviducts* (Fallopian tubes, &c.) or canals leading from the ovarium to the uterus; and lastly, those at least which are impregnated by a real copulation, possess a *vagina,* or canal, connecting the uterus to the external organs of generation.

In birds, all the parts which we have just mentioned are single, excepting the ovaries, which in many birds are double. Some cartilaginous fishes have two oviducts, beginning, however, by a common opening, and terminating in a simple uterus. The human female, as well as that of many other mammalia, has two ovaria, with an oviduct belonging to each, a simple uterus, and vagina. The females of this class, in several other instances, possess an *uterus bicornis;* and, in some cases, the generative organs are double throughout; that is, there are two uteri, and, at least for some extent, a double vagina, as in the *opossum.* (Vid. Plate VII.)

Ovaria are found in the females of all animals where the male possesses *testicles;* but their structure is in general more simple than that of the latter glands, particularly in the first class. These bodies were formerly called the *female testicles,* but the term *ovary* is much preferable, as it denotes the function which the parts perform in the animal economy. For, if the office of these bodies be at all dubious, when their structure is considered in man and most of the mammalia, their organization is so evident in the other classes, that no doubt can be entertained respecting their physiology. It is manifest in all these, that the ovaria serve for the growth and preservation of the germs, or ova, which exist in these bodies completely formed before the act of copulation. Analogy leads us to conclude that these bodies have the same office in the mammalia, and thus our explanation and illustration of this most interesting part of physiology are entirely derived from researches in comparative anatomy.

MAMMALIA.

§ 334. Of the external female sexual organs in this class, the clitoris is most generally found,* for it exists even in the whales,† and probably is wanting in no other instance than the ornithorhynchus.‡

As this organ, in its general structure, bears considerable resemblance to the male penis, it contains a small bone in several species of mammalia, as the *marmota citillus*, the *racoon*, (*ursus lotor*) the *lioness*, the *sea-otter*, &c. In the *opossum* it possesses a bifid glans, like that of the penis. (Vid. PLATE VII.) The analogy between the two organs is carried so far in the *lori*, (*lemur tardigradus*) that the urethra runs through the organ and terminates on its anterior extremity.§ In the *rat*, the *domestic mouse*, the *hamster*, &c. the clitoris and the orifice of the urethra are placed at some distance from the vagina, and in front of that part. This structure has sometimes been mistaken for a preternatural hermaphrodite formation.||

In consequence of the horizontal position of the body of quadrupeds, the clitoris is at the under-margin of the orifice of the vagina, instead of the upper one, as in women.

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* Linnæus considered this organ to be a peculiar mark of distinction between the human female and that of the simiæ ; whereas, in the latter animals, it is generally remarkably large. I found it of very considerable magnitude in a mandrill, (*papio maimon*) which I dissected.

† Tyson's *Anat. of a Porpoise*, tab. 2, fig. 3.

In a *balæna boops* of fifty-two feet in length, this part was very large, even in proportion to the monstrous size of the animal.

‡ Home, in the *Phil. Trans.* 1802, p. 81.

§ Aubert, *Hist. Nat. des Singes*, tab. 2, fig. 8, of the anatomical figures.

|| J. J. Döbel, in *Nov. Literar. Maris Balthici*, 1698, p. 238.

Jo. Faber, in his remarks on F. Hernandez, *Plantar.* &c. *Mexicanar. Histor.* p. 547.

It is much larger in the simiæ than in women. The *lemur*, (macauco) the *carnivora*, and most of the *rodentia*, have it also very large.

None of the mammalia possess nymphæ; and there is generally merely a thin border of the integuments instead of labia pudendi.

§ 335. A true *hymen*, or one at least, which in form and situation resembles that of the human subject, has been observed in no other animal. The well-known membranous valve, covering the orifice of the meatus urinarius in the vagina of the mare, can by no means be considered as a hymen.*

Cuvier considers the opening of the urethra as forming the distinction in quadrupeds between the *vulva* and the *vagina;* now this aperture is situated in many animals at a considerable distance within the external opening of the genitals.

There is a contracted circle in this situation in the *otter*, *dog*, *cat*, and ruminating animals, which he considers as analogous to the hymen. He mentions also the existence of a considerable fold in the *bear* and *hyena*, in this situation; and that he has found a manifest hymen in the hyrax. According to the same author, the *mare* and *ass*, and some of the simiæ, have an analogous structure. Hence he concludes, that the hymen is not a part exclusively peculiar to the human species. *Leçons d'Anat. comp.* tom. v. pp. 128, 133. It appears, however, clearly from his own descriptions that the parts in the above-mentioned animals only bear a remote resemblance to the human hymen.

§ 336. The vagina of quadrupeds is distinguished from that of the human subject by two chief characters: its direction, and the structure of its internal surface. In consequence of the form and position of the pelvis, this canal lies in the same axis with the uterus, or at least with the neck of that organ. The glandular membrane, which constitutes its internal coat, forms none of those extremely elegant transverse plaits, which distinguish it in the human female, but is merely folded longitudinally. If transverse folds exist in any instance, they are either confined to the immediate neighbourhood of the external opening, as in the *cow;* or, if they extend farther, as in the *simiæ,* they do not possess that regular arrangement or beautiful formation which are displayed in the human female.*

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* Ruini, p. 164. Daubenton, tom. iv. tab. 4, fig. 2; and tab. 8.

Bourgelat, *loco citato*, p. 383.

Brugnone, *Mém. de l'Acad. des Sc. de Turin*, tom. iv. p. 406.

The description of a similar part in the manati of Kamtschatka (*trichechus manatus*) may be seen in the *Nov. Comment. Acad. Petropolitan.* tom. ii. p. 308; and on the hymen in animals consult Duvernoy, in the *Mémoires présentés à l'Institut. de France, Scs. Physiques*, tom. ii. p. 89.

Dr. Gärtner of Copenhagen has recently called the attention of anatomists to the existence of two canals in the vagina and uterus of the *cow,* and some other mammalia. These canals commence in the neighbourhood of the Fallopian tubes, and open into the vagina near the meatus urinarius. They exist also in the *sow;* neither age nor gestation makes any difference, they are always present. In the *sow* these canals commence by two openings situated on the sides of the orifice of the urethra, run obliquely from within outwards, in the substance of the parietes of the vagina, and also a little upwards, thus describing a curve. In this course they receive lateral branches coming from the neighbouring glands, the union of which forms a mass rather analogous in its external appearance to the pancreas; they diminish necessarily in size as they receive fewer of these small lateral ducts, and especially in the part of the parietes of the vagina which is continuous with the cornua of the uterus. They are always present, but are found more developed a short time after conception. In a *sow,* whose uterus contained some fœtuses from two to three inches in length, the diameter of these canals was very considerable; they extended even in the substance of the broad ligaments to within a few inches from the ovaries, where they apparently terminated in several small glandular bodies. The prolongation of these canals into the broad ligaments was very evident; their appearance was white and opaque, but it was easy to inject them with quicksilver; in some points they were considerably, and appeared in some others completely obliterated.

In the cow, the vaginal orifice of these canals is larger, situated more in front, and on the side of the meatus urinarius; these canals are continued the whole length of the lateral parietes of the vagina, nearly to a level with the orifice of the uterus, where they appeared all of a sudden to terminate. But an attentive examination shewed that they penetrate into the cellular substance on the neck of the womb, and re-appear on the body of the uterus, along which they are continued to the cornua, and thence to within a short distance from the ovaries. These canals are invariably to be found in the course which we have just mentioned. In some young *cows* the uterine portion of these canals is extremely fine; in others, on the contrary, it is somewhat dilated. The part of the canals corresponding to the neck of the uterus is subject to several varieties, resulting principally from the age and the gestation of the animal. See *The Lancet*, vol. ix. p. 273.

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* A representation of the vagina of the *mare* laid open, may be seen in Daubenton, tom. iv. tab. 4, fig. 2.

That of the *cow,* in Nic. Hoboken, *Anat. Secundinæ Vitulinæ.* Ultraject. 1675, 8vo. fig. 3; and in J. G. Eberhard, *Over het verlossen der Koeijen.* Amsterdam, 1793, 8vo. tab. 1.

Of the *ewe,* Fab. ab Aquapendente, *De formato Fœtu,* tab. 17, fig. 35 and 36; and De Graaf, *De Mulierum Organis,* tab. 20.

Of the *hind,* Daubenton, tom. vi. tab. 17.

Of the *rat,* ibid. tom. vii. tab. 38, fig. 3.

Of the *genet,* (*viverra genetta*) ibid. tom. ix. tab. 37, fig. 2.

Of the *panther,* ibid. tab. 16.

§ 337. The structure and form of the uterus vary very considerably in this class. In no instance does it possess that thickness, nor has its parenchyma that density and toughness which are observed in the human female.* Of those which I have dissected, the *simia sylvanus* had comparatively the firmest uterus. The *two-toed ant-eater* came the next in order in this respect. But in the greater number of mammalia this organ is thin in its coats, resembling an intestine in appearance, and provided with a true muscular covering.

§ 338. The variations in form of the impregnated uterus may be reduced to the following heads:

1. The simple uterus without horns (*uterus simplex*) which is generally of a pyramidal or oval figure. This is exemplified in those animals where we have stated that it possesses thick coats. Its circumference in some *simiæ* presents a more triangular form than in the woman: and towards the upper part, in the neighbourhood of the Fallopian tubes, there is an obscure division into two blind sacs† (as in the *gibbon*, or *long-armed ape*); this distinction is more strongly expressed in the

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* "*Uterus humanus,*" (says Haller,) "*ab omnium animalium uteris differt, quæ ego inciderim. Quadrupedum uterus verus est musculus, pene ut æsophagus. Crassior etiam est in homine quam in ullo animale.*" *Element. Physiol.* tom. vii. pt. 2, p. 50. "The human uterus is different from that of all animals which I have met with. In quadrupeds this organ is a true muscle, something like the œsophagus. It is thicker in man than in any animal."

† Daubenton, tom. xiv. tab. 5, fig. 2.

lori, (*lemur tardigradus*) so as to form a manifest approach to the *uterus bicornis*.*

2. A simple uterus with straight or convoluted horns (*uterus bicornis*). They are straight in the *bitch*,† in the *racoon*, in the *bats* of this country, (Germany) in the *sea-otter*, *seal*, &c.‡ somewhat convoluted in the *cetacea*,§ *mare*,|| and *hedgehog*, and still more tortuous in the *bisulca*.¶

3. A double uterus, having the appearance of two horns, which open separately into the vagina; this is seen in the *hare*,** *mole*, and *rabbit*†† (*uterus duplex*).

4. A double uterus, with extraordinary lateral convolutions, is met with in the *opossum* and *kangaroo*‡‡ (*uterus anfractuosus*). *Vid.* PLATE VII.

After I had dissected this curious part in a fresh *opossum*, I began to understand the obscure and in part contradictory descriptions given by others, and I trust that the plate (vii) at the end of this volume will be found not only intelligible, as compared with those by Tyson, Daubenton, and several others, but sufficiently clear to give an idea of these parts to those who may not have had the opportunity of dissecting them.

As the process of generation in these singular animals deviates very considerably, in some of its parts, from the same function, as observed in the other mammalia, a considerable difference is found in the generative organs; of which, as the subject is a very interesting one, we shall present the reader with a more detailed description, as

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* Ibid. tab. 31, fig. 4.

† Vesalius, p. 585, ed. of 1555.

‡ Daubenton, tom. ix. tab. 16, of the *panther*; tab. 33, of the *civet*; tab. 37, fig. 2, and tab. 38, 39, of the *genet*; tom. xiii. tab. 51, of the *seal*.

§ Tyson, tab. 2, fig. 3.

|| La Fosse, tab. 45, 46.

¶ It is represented in the *sheep*, by De Graaf, tab. 20.
In the *cow*, by Hoboken, fig. 29, 30; by Eberhard, tab. 1.

** Daubenton, tom. vi. tab. 45.

†† De Graaf, tab. 25; Daubenton, *loc. cit.* tab. 56.

‡‡ Home, in the *Philos. Trans.* for 1795, tab. 18, fig. 1; tab. 19, fig. 3; for 1808, p. 310; and 1810, pt. 2.

well with reference to the male as to the female, from the 3rd vol. of Sir. E. Home's Lectures on *Comparative Anatomy*.

With respect to the male organs of generation, Sir E. Home found at the orifice of the prepuce, two delicately formed processes of a very bright red colour; the orifice of the urethra lay between them, with a groove extending to the point of each; they were half an inch long, and bore an exact resemblance to the double tongue of the snake.

From this mechanism it will be found, that in the act of copulation, the double glans is not denuded till the penis has arrived at the end of the vagina, being too delicate to bear the resistance of the more external parts.

The testicles are pendulous, hanging in a scrotum, with a narrow neck, a little before the common opening of the anus and the passage for the penis.

In the female, the organs of generation do not appear externally, there being one common opening surrounded by cuticle covered with hair; for both the vagina and rectum, and the two canals, are separated from one another, by means of a septum of no considerable thickness.

The common orifice is projected beyond the bones of the pelvis above two inches, and this prominent portion admits of considerable motion.

At the external orifice of the vagina is situated the clitoris, which, when compared with the other parts, may be said to be large; it is inclosed in a preputium; a little way further on in the vagina, are two orifices, the openings of the ducts of Cowper's glands. The vagina itself is about an inch and a half in length, beyond which it leads into two lateral canals; and on the edge formed between them, opens the meatus urinarius, leading to the urinary bladder.

These canals are extremely narrow for about a quarter of an inch in length, and at this part their coats are very thick; they afterwards become more dilated and membranous; they diverge in their course, and pass upwards for nearly four inches in length; they then bend towards each other, so as to terminate laterally in the two angles of the fundus of the uterus.

The uterus is extremely thin and membranous in its coats, slightly infundibular in its shape, and situated in the middle line between the two canals.

In the virgin state it is impervious, so that at that time there is no communication with the vagina, except by the lateral canals.

The same internal membrane that lines the lateral canals, appears to line the uterus; it is thrown into folds equally so in the uterus and canals, and a broader fold than the rest marks a division of the uterus into two equal parts.

The ovaria and fimbriæ resemble those of quadrupeds: the Fallopian tubes follow nearly the same course to the uterus as in the quadrupeds; but a little way before they reach it they dilate considerably, forming an oval enlargement, the coats of which are much thicker than those of the other parts, and the supply of blood-vessels much greater, so that there is no doubt of its performing some peculiar office; beyond this part the tubes contract and pass perpendicularly through the coats of the uterus at its fundus, and terminate in two projecting orifices, one on each side of the middle ridge just mentioned.

The ovaria in the *kangaroo* are similar to those of quadrupeds in general, have corpora lutea produced in them, and in these the ova are formed. When magnified four diameters, the appearance of the structure of the corpus luteum is beautifully distinct.

From these examinations it would appear that commonly the *kangaroo* has only one young at a time; for although in one ovarium there are the rudiments of two corpora lutea, they are in different degrees of advancement.

It is evident that both ovaria are forming corpora lutea at the same time, but they are in very different stages.

As the ovum in this animal is not afterwards to be attached to the uterus, there can be no doubt that the thickened oval portion of the Fallopian tube, near its termination in the uterus, which extends to the depending orifice, is to supply something analogous to yolk, which is to attach itself to the ovum before it drops into the cavity; it is afterwards supplied by albumen from the internal surface of the two lateral tubes; in the same manner as albumen is formed in the oviducts of birds.

The structure of the coats of the oval enlargement of the Fallopian tube is of a very uncommon kind; it does not resemble any known gland in the body employed for secretion; the yolk is oil or fat in a most exceedingly concentrated state, which, according to Sir E. Home, is formed in the intestine generally, but in some animals in the liver; and after being received into the circulation, is deposited by the terminations of arteries whenever wanted. Nothing can better accord with this idea, says Sir E. Home, than the apparatus set up in the Fallopian tube; there is an arterial trunk at some distance, of considerable size, which sends off an infinite number of branches, nearly of the same length, and all terminating in this oval portion of the tube. This is perhaps the only structure to be met with of the kind, probably also the only occasion in which concentrated oil is required to be suddenly collected.

When the ovum arrives at the uterus, it is enveloped in an abundant quantity of albumen. There was nothing like shell, and the soft ovum had been too long preserved in spirit to retain its natural appearance, it was reduced to a pulp. The uterus and the lateral tubes were filled with this jelly, and the os tincæ plugged up with it; the lateral tubes were open into the vagina. In the cavity of the uterus, in the midst of this coagulated jelly, was a small portion of the rudiments of a fœtus.

The mode in which impregnation takes place has not been satisfactorily explained; but Sir E. Home has now no doubt that the semen is conveyed into the uterus through the two lateral canals, and is there applied to the albumen in which the molecule corresponding to the human ovum is enveloped, and the embryo is afterwards aerated by means of the atmosphere through the openings into the lateral canals from the vagina.

How long it requires for the ovum to be hatched in utero, is not even at this day ascertained; whenever that happens, the young is propelled into the marsupium through the os tincæ which opens for that purpose. There it becomes attached to the point of the nipple.

The mammæ are two in number; each of them has two nipples; they are not placed upon the abdominal muscles, as in other quadrupeds, but are situated between two moveable bones connected to the os pubis, and the mammæ are supported upon a pair of muscles which arise from these bones, and unite in the middle between them.

These mammæ are covered anteriorly by the lining of the false belly, and the nipples project into that cavity; this covering is similar to the external skin, having a cuticle, and short hair thinly scattered over its surface, except at the root of the nipples, where there are tufts of some length, one at the basis of each.

The mammæ are supplied with blood from the epigastric arteries. The mammary branches run superficially under the false belly till they reach the mammæ. There is a strong muscle which comes down from the upper part of the abdominal muscles, and adheres firmly to each of the mammæ; this prevents the gland from being dragged from its natural situation while the young is suckling.

The two bones that lie behind the mammæ deserve a particular description, as they are met with in the whole tribe that have false bellies, and are not even peculiar to them, in some degree belonging to other animals, as the crocodile; they go to the mammæ, and have no other use but what is connected with the motion of these parts.

They are about two inches and a half long, are flattened, and at their broadest part measure nearly half an inch; they are attached to the projecting part of the os pubis, which is fitted for that purpose, just before the insertion of the recti muscles; this attachment to the pubis is by a very small surface, and admits of considerable motion. They have likewise a connexion by a ligament half an inch in breadth, to the ramus of the pubis which joins the ileum. From their base, which is united to the pubis, they become narrower till they terminate in a blunted point. These bones have a pair of muscles inserted into their base, to bring them downwards and outwards; another pair is connected to their blunted extremities to bring them forwards; a pair of broad flat muscles fills up the whole space between them, arising from their inner edge through its whole length; these last serve as a sling to support the mammæ, and also to bring the bones towards each other.

Besides these additional bones, and the projection to which they are attached, there is another peculiarity in the structure of the pelvis of the female; the two rami of the os ischium which join the pubis, have no notch between them, as in other quadrupeds, but form a round convex surface of some breadth, projecting considerably forwards. The surface itself is smooth, like those over which tendons pass; but the lateral parts are rough, and have a pair of muscles arising from them, inserted into the skin of the false belly, to bring its mouth towards the pudendum.

The mode in which the young passes from the uterus into the false belly, has been matter of much speculation; and it has even been supposed that there was an internal communication between these cavities. This idea took its rise from there being no visible opening between the uterus and vagina during impregnation; but such an opening remaining of some size after parturition, explains the mode in which the young passes out; and the false belly or bag having muscles, which must, when they are in action, bring both the orifice and the mammæ themselves close to the vulva, removes all theoretical objections against the young getting to the nipple; particularly as the vulva has naturally an unusual projection, and the margin of the pelvis immediately before it is rounded and smooth, so to admit of its moving easily in that direction. The very action of opening the mouth of the false belly, by bringing down the skin, will allow the external orifice of the vagina to be thrown still further out, so as to project more directly over the mouth of the false belly in which the fœtus is to be deposited.

It is to be observed, that as all these circumstances belong to the parts in a natural state, they will be much increased at the period at which parturition takes place, since in all animals at that particular time, there are changes going on to facilitate the expulsion of the young in the way most favourable for its preservation. The size of the young at this period is not exactly known.

When the young is first attached to the nipple, the face appears to be wanting, except a round hole at the muzzle to which the nipple is applied and adheres; soon after, the lips and jaws grow upon the nipple, till at last nearly half an inch of its length is enclosed in the mouth.

The kangaroo has only one young at a time, which may be seen attached by the mouth to the nipple inside the mother's pouch, from the period it is the size of your thumb-top, and as unshapely as a new-born mouse, until it attains the size of a poodle-dog, with a fine glossy coat of hair, ready to leap out and hop along after the mother. The young are attached by the mouth to the nipple in somewhat the same way as the placenta of other animals is attached to the uterus, the mouth being contracted round the nipple, which swells out like a cherry inside it, nourishing the fœtus by way of absorption through this indirect channel, the mouth and nipple adhering so strongly, that it requires considerable force to separate them. When the fœtus arrives at sufficient age to suck, it drops off the nipple, and may then be said to be born, yet still continuing inside of the pouch, and sucking milk now through the ducts of that same nipple, from the external surface of which it formerly derived a very different species of nourishment. The manner in which the young reach this pouch from the ovary, and attach themselves to the nipple, is still a mystery, as no communicating duct has yet been found; but the natives assert they are born in the usual way, and that the mother places them there. It is amusing to see the young kangaroo pop its head out of the pouch, when the mother is grazing, and nibble, too, at the tender herbage which she is passing over. When hard hunted, the mother will stop suddenly, thrust her fore-paws into her pouch, drag out the young one, and throw it away, that she may hop lighter along. They are always very hard pressed, however, before they thus sacrifice the life of their offspring to save their own; and it is pitiful to see the tender sympathetic looks they will sometimes cast back at the poor little helpless creature they have been forced to desert. From this singular mode of gestation, you may handle the fœtus in utero, and pull it about by the tail like a kitten, from the first moment of its appearance there, up to the very day of its birth, without causing either pain or annoyance to it or its mother. Such is the very singular manner in which nearly all our Australian quadrupeds are generated and brought forth. When the young kangaroo has attained a considerable size, it will crawl out, feed about, and creep in again to warm itself, or in case any danger approaches. The kangaroos feed early in the morning when the dew is on the grass, which is the best time to hunt them. See Cunningham's *Two Years' Residence in New South Wales.* London, 1827.

Externally there is no appearance of organs either in the male or female ornithorhynchus, the orifice of the anus being common to the rectum and penis in the male, and to the rectum and vagina in the female. After the most careful search, says Sir E. Home, there was not the slightest appearance of nipple. The male is distinguished from the female by no other external appearance than the spur, which is attached to the heels of both the hind feet; it is half an inch in length, with a sharp point. There is a joint between the spur and the heel, admitting of motion in two directions, one that brings it in towards the body, in which state it lies concealed; the other throws it onwards, and renders it very conspicuous.

These spurs, Sir John Jameson, resident in New South Wales, who has the opportunity of examining the parts in a recent state, declared to be tubular, and gave to the Linnæan Society a paper on that subject some years ago; he also mentioned that some of the natives, who had been wounded by them, asserted that they emitted a liquor of a poisonous nature. In examining the parts, after being long kept in spirits, no such structure was met with; and when the spurs were boiled, the cavity appeared to be similar to that of the cock, only filled with a pulp instead of a core; this, however, Sir E. Home has since discovered to be an artificial appearance, the effect of coagulation. Upon examining the spur in a better state of preservation, Sir E. Home not only found a membranous tube passing through the spur, which has an orifice on one side, near the point; but Mr. Clift succeeded in injecting a duct leading to a gland which lies across the back part of the thigh, over the muscles, one inch and more in length, and half an inch broad; the excretory duct passes like the ureter of the kidney out of one side, near the middle. The quicksilver injected immediately pervaded every part of the gland; and when the point of the pipe was turned downwards, ran readily to the root of the spur, where the duct made a turn, and formed a small reservoir. After a little time, however, the mucus being gently squeezed and pressed forward, we saw the mercury in the spur, and at last it came out of the orifice.

A secretion is emitted through the spur of the male into this socket, and the parts are so minute as to require glasses of considerable power. Mr. Bauer examined the socket in the female, and after overcoming considerable difficulties, the parts being very much corrugated, and yet retaining their elasticity, he made out the form of this socket, which corresponds exactly in shape with the spur itself, so that when completely introduced, it must be so grasped that the male would be unable to withdraw it when the coitus was over, in this respect resembling the effect of suction.

The testicles are situated in the cavity in the abdomen, immediately below the kidneys; they are large for the size of the animal. The epididymis is connected to the body of the testicle by a broad membrane, which admits of its lying very loose. The penis of the male has a structure of a very extraordinary nature. The urine does not pass along the urethra of the penis; it is conducted by a distinct canal, which opens into the rectum, an inch above the external orifice of that gut. On each side at this part is a large solid body, the size of a testicle, which proves to be a gland; each of these has a small excretory duct, which passes to the root of the penis, where they unite, and then open by one common orifice into the seminal urethra, one tenth of an inch after it has entered the penis.

These glands must be considered to correspond with Cowper's glands in the human body, and not as either a substitute for prostate gland or vesiculæ seminales, since they are met with in the female.

In the female they are smaller than in the male. Their ducts open by one common aperture on the posterior surface of the vagina, one-fourth of an inch within the orifice of that canal.

The penis, which is solely appropriated for the passage of the semen is very short, when in a relaxed state, nor is it capable of being much elongated, when erection takes place. The prepuce is a fold of the internal membrane of the verge of the anus, as in the birds, and the penis when retracted is entirely concealed.

The urethra leads directly from the bladder to the rectum; near the double glands it divides into two, one going to each; and instead of there being a single external orifice, as is usual in other animals, one terminates in five small prominent papillæ, the other in four; they take different directions, corresponding to the two openings of the uterus of the female; the urethra swells out into a cavity in the centre of each glans, and thence communicates with all the papillæ, whose orifices are the size of hairs. When water is injected through the urethra, the mode in which it is scattered by the nine orifices of the papillæ, exactly resembles the pouring water out of a watering pot.

The vasa deferentia open into the membranous part of the urethra before it reaches the penis.

The female organs open into the rectum as in birds; just within the anus there is a valvular projection between the rectum and vagina; it is slender, half an inch long, bifid at the point, and enclosed in a prepuce, the end of the glans only projecting into the vestibulum. The vagina is about one inch and a half long, its internal membrane rugous, the rugæ being in a longitudinal direction; at the end of the vagina is the meatus urinarius, and on its two sides are the openings leading to the utera. This corresponds as nearly as can be to the *kangaroo* and the *opossum*, only in this animal the uterus in the middle of the vagina is wanting, and on each side, in place of the lateral canals, there are two uteri in form approaching to the oviducts of birds. At the end of each uterus there is a small ovarium covered by a capsule.

When the ovarium was examined by Mr. Bauer, it was found to be filled with yolk bags, less deeply imbedded in its substance than those of the American opossum, bearing a greater resemblance to the yolk bags of the fowl; and to make this resemblance more intelligible they were compared together; the great difference between them is, the covering of the ovarium in this animal being strong and opaque, while there is no such outer coat in the fowl, and the clutch of yolk-bags is double in the *ornithorhynchi*, and single in the birds.

There is an approach to this in the bird, in which there is only one ovarium and one oviduct; but in the chick of the *common fowl*, before it is hatched, there is a small portion of an incipient oviduct on the right side; but this disappears before the chick is completely formed.

As the *ornithorhynchus paradoxus* resembles the *opossum* tribe in having a vagina and a penis, these animals copulate exactly like the quadruped, which made it difficult to understand where the ovum was brought to perfection. The uteri appeared not to be convenient situations; and yet, if not there, the position of the meatus urinarius seemed to preclude an ovum from having a shell formed in the vagina or cloacus, at the rectum, a necessary protection before it could be laid externally.

The second series of *ornithorhynchus* we have called *hystrix;* however much it differs from the other in its external appearances and habits, it resembles it nearly in the organs of generation; it is an inhabitant of New South Wales. One of this species was shot in Endeavour Bay, by Van Diemen's land; it was seventeen inches long, and when it walked, the body was two inches from the ground.

The animal which Sir E. Home examined was a male; externally there was no appearance of organs of generation, in this respect being exactly similar to the paradoxus. Just at the setting on of the heel the hind legs had the same spur already described in the other species; there was also a gland on the posterior part on the thigh, and a duct leading from it to the spur, but smaller than in the *paradoxus.*

The male organs resemble those of the *paradoxus* in the form and situation of the testicles, the opening of the vasa deferentia, and the opening of the urinary urethra into the rectum, as well as that of the seminal urethra, which runs in the middle line of the penis.

The penis is very elastic in its substance: when drawn out is about three inches long; in a natural state, before it was hardened in spirit, it of course could be farther extended. The glans is divided into four portions of equal length, two facing to the right, and two to the left, so that there are evidently two adapted to each uterus. All these have an orifice in their centre, surrounded by concentric circles of infinitely small prominent papillæ.

The female organs Sir E. Home has not seen, but the correspondence there is between those of the male in the two different kinds, implies a similarity in those of the female.

The hystrix in many parts of its form is a nearer approach to the more perfect quadrupeds than the *paradoxus;* and as its tongue is in some respects like those of the *manis* and *myrmecophaga*, it was natural to look among the different species of these genera for other points of resemblance.

§ 339. These various forms undergo different changes in the pregnant state.

The alteration in the simple uterus is, on the whole, analogous to that which occurs in the human female.

The pregnant *uterus bicornis* suffers a different change in those animals, which bear only one at a time, from that which it undergoes in the *multipara*. The fœtus of the *mare* is confined in its situation to the proper uterus.* In the *cow* it extends at the same time into one of the horns, which is enlarged for its reception.* In those, on the contrary, which bring forth many young at once, as also in the double uterus of the *hare* and *rabbit*, both cornua are divided by contracted portions into a number of pouches corresponding to that of the young; and where those horns are straight in the unimpregnated state, as in the *bitch*, they become convoluted.†

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* Ruini, p. 181 *et seq.* Fab. ab Aquapendente, tab. 20, 21.

The uterus anfractuosus of the marsupial animals undergoes the least change from its usual appearance in the impregnated state. For these strange animals bring their young into the world so disproportionately small, that they appear like early abortions.

§ 340. The *Fallopian tubes* are convoluted upon each other in a kind of knob in some instances, as the *simia sylvanus*, and still more remarkably in the *opossum*. The *fimbriæ* are sometimes shaped like a funnel, as in the *rabbit*.

§ 341. The *ovaria* are generally of an oval form, and have the *ovula Graafiana* buried in their parenchyma. These vesicles, however, project externally in some cases, as in the *pig*; where the ovaries appear tuberculated on the surface.‡ In the *hedgehog* they are quite loose and separate, so that the ovary resembles a bunch of grapes, and thereby approaches to the structure of the bird.

The number of vesicles appears to accord on the whole with that of the young which a mother is capable of producing during her life.§

The wild and domesticated races of the same species of animals differ very remarkably in their fertility: which difference furnishes a new and strong argument against the supposed pre-existence of previously formed germs in the female ovary. The domestic *sow* brings forth commonly two litters in the year, each of which consists, perhaps, of twenty young ones. The wild animal, on the contrary, becomes pregnant only once in the year, and the number of its young never exceeds ten. Both reach about the same age, viz. twenty years.

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* Hoboken, fig. 1, 6, 31. Eberhard, tab. 9, 10.

† Fab. ab Aquapendente, tab. 28, of the *bitch*.

Id. tab. 24, of the *pig*; also Daubenton, tom. v. tab. 20.

Id. tab. 29, of the *mouse*.

Id. tab. 30, of the *guinea-pig*.

‡ Wrisberg, in the *Comment. Soc. Reg. Scient. Göetting.* tom. iv. p. 69.

§ Hunter, in the *Philos. Trans.* vol. lxxvii. p. 233.

A similar difference is found to obtain between the tame and wild cats; as also between the *domestic dove* and the *wood-pigeon*. How should those domestic animals, which descend from the original wild stock, produce such a remarkably greater number of young ones, if these are merely to be evolved from germs, which have existed since the first creation of things?

And the *corpora lutea*,* which have received this name from their colour in the ovaries of the cow, are probably never found in the quadruped, except after impregnation.

I have shewn in the *Comment. Soc. Goetting.* tom. ix. p. 109, that corpora lutea may be formed in the ovaria of virgins, as empty *calices* are sometimes met with in those of birds which have not copulated; and have also pointed out under what circumstances this takes place.†

BIRDS.

§ 342. The female organs of generation in this class may be most conveniently arranged under three divisions: the external parts including the *cloaca;* the *tubus genitalis* (oviduct) resembling an intestine; and lastly the *ovarium*, which is almost entirely separate from the latter part.

As the general structure of these parts is very uniform in all birds, we may take as an example the most familiarly known species, the *hen*.‡

§ 343. The *external* opening of the genitals consists of a

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* Vide Sir E. Home, in the *Phil. Trans.* for 1819, p. 59, with excellent plates of these parts in the *cow* and *sow*.

† G. Spangenberg, *Disquisitio circa partes genitales fœmineas Avium.* Goett. 1813.

‡ For the sake of brevity, I refer once for all in this description of the generative organs of birds, to the excellent delineations by Ulmus, in Aldrovandi's *Ornitholog.* tom. ii. p. 209, ed. of 1637; and by De Graaf, tab. 18; and to Spangenberg's work.

transverse slit behind the ossa pubis, which do not form a symphysis; this is larger in the *hen* than in the *cock;* and its smaller anterior labium is covered by the larger posterior one (*velabrum*).

This slit leads to the cloaca, in which several organs open, (§ 114). These are the rectum; the two ureters on the prominent margin of that part; the vagina on the left; behind which, and on the upper part of the cloaca, there is the *bursa Fabricii.*

The opinion of the celebrated anatomist, whose name this mysterious organ bears; that it receives and retains the semen of the *cock,* is refuted by this circumstance among many others, viz. that the part in question is found also in the *cock,* where it is actually much larger than in the hen; nay, it is often so small in the latter, that its very existence has lately been denied. This however is going too far. For I have never failed in finding it, at least in young *hens,* although it is sometimes no longer than a barley-corn, and instead of being loose, as in the *cock,* is closely invested by cellular substance, so that its demonstration requires some care and attention. The opening, by which it may be inflated, is found on the superior surface of the cloaca, behind the termination of the rectum, and on the front edge of a small eminence (*scutellum*) the size and development of which seem to be in an inverse ratio to those of the bursa.

From all the observations which I have been able to make on this part (which Perrault very inappropriately termed *le troisième cœcum*) I am led to conclude, that the function, which forms its final use, must belong to the male, and that it is only to be considered as a mechanical rudiment in the hen, thereby affording another example of the union of the two principles in the *formative impulse.*

In the present instance the teleogical principle is manifested in the bursa of the *cock,* and the mechanical in that of the *hen.* In the breasts, on the contrary, the case is reversed; the teleogical principle prevails in the female sex, where the final use or purpose of the glands is discerned; and these parts are formed in the male, merely as rudiments, in compliance with the mechanical principle.

§ 344. In the *tubus genitalis,* which considerably resembles an intestine, and is really on the whole very uniform in its appearance, we may however distinguish three parts. The vagina, the proper *uterus,* and the *oviductus;* the latter part terminates in the *infundibulum,* which is very different in its structure and appearance.

The *vagina* is about one inch and a half long, and very extensile: it follows a tortuous course.

The *uterus* is about the same length, but larger and thicker in its parietes, and folded internally.

The *oviductus* (in French *la portière*) appears like a continuation of the last mentioned part; it is about one foot and a half long, convoluted like an intestine, and though slightly contracted at intervals, on the whole conical, so that it decreases in diameter to the infundibulum. Its internal coat is covered with innumerable papillæ, which secrete the white of the egg; and the whole tube is connected above to the spine by a kind of mesentery (*mesometrium* or *meserœon uteri*).

It opens by its small end into the *infundibulum,* which is an expanded part, analogous to the fimbriated extremity of the Fallopian tube, for receiving the yolk from the ovarium. This infundibulum is formed of a delicate membrane, with a very elegantly folded margin, which is connected behind to the uterus by means of a round tendinous cord.*

In speaking of the uterus and vagina of birds, the author does not sufficiently keep up the distinction which ought to be observed between an *uterus* and an *oviduct.*

The germ, or ovum, passes from the ovarium through a canal, which either conveys it out of the body, (as in the case of the egg) or transmits it into another organ. The latter is a cavity, admitting of enlargement, and having the germ attached to its parietes by means of vessels, which nourish and preserve it until it has acquired a certain development.

The first mentioned organs are found in all the four classes of vertebral animals: they are called *Fallopian tubes* in the mammalia, and *oviducts* in the three other classes. The latter belongs to the mammalia only, and is their *uterus*. We find, however, that the author speaks of the uterus of other classes: the difference in the office of the parts is so striking that they should on no account be confounded together.

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* Two oviducts have been sometimes discovered in hens. Vide Stenonis, in 2nd vol. of the *Act. Havn.* p. 226; and Morgagni's *Epist. Anat. XX.* note 31.

§ 345. The *ovarium*, resembling in its appearance a bunch of grapes, lies under the liver, and contains in a young laying *hen* about five hundred yolks, varying in size from a pin's head to their perfect magnitude; the largest always occupy the external circumference of the part. Each yolk is inclosed in a membrane (*calyx*) which is joined to the ovarium by means of a short stalk or pedicle (*petiolus*). A white shining line forms on the calyx when the yolk has attained its complete magnitude. The membrane bursting in this part, the contained yolk escapes, and is taken up by the infundibulum in a manner which we cannot easily conceive.* It then passes along the oviduct, and acquires in its passage the white and shell.† The calyx, on the contrary, remains connected to the ovarium; but it contracts and diminishes in size, so that in old *hens* which have done laying, the whole internal organs of generation nearly disappear. This forms one of the many instances in the animal economy of remarkable and peculiar motions, which cannot be referred to any of the general vital and motive powers, as contractility, irritability, &c. according to the physiological notions which have been hitherto affixed to those terms. Hence I have arranged them as specimens of a peculiar principle, or *vita propria*, without presuming to give any explanation of the subject. This term will serve to denote and distinguish them until the received opinions on the above-mentioned general vital powers shall have been so far altered or modified as to include these peculiar cases.‡

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* Wepfer, *Cicutæ Aquaticæ Historia et Noxæ*, p. 173.

† Vide Dutrochet, in the *Journal de Physique*, tom. lxxxviii.

‡ I have entered more fully into this subject in my *Curæ iteratæ de vi vitali sanguini deneganda, vita autem propria solidis quibusdam Corporis Humani partibus adserenda.* Goettingen, 1795, 4to.

AMPHIBIA.

§ 346. The *tortoise* has a manifest clitoris, lying in the cloaca. The uterus, oviduct, and ovarium, have on the whole much analogy with those of birds; but all these parts are double, and have two openings into the cloaca.* The two uteri are thick and fleshy, while the oviducts are thin and delicate.

§ 347. The *frogs* of this country (Germany) have a large uterus, divided by an internal partition into two cavities, from which two long convoluted oviducts arise and terminate by open orifices at the sides of the heart. The ovaria lie under the liver, so that it is difficult to conceive how the ova get into the above-mentioned openings. The uterus opens into the cloaca.†

The *toads* have not the large uterus; but their oviducts terminate by a common tube in the cloaca.‡

§ 348. The *lizards* of this country (Germany) have on the whole a similar structure to that of the last-mentioned animals. Their oviducts are larger, but shorter, and the ovaria contain fewer ova.

§ 349. Female *serpents* have double external openings of the genitals for the reception of the double organs of the male. The oviducts are long and much convoluted. The ovaria resemble rows of beads, composed of yellow vesicles.

FISHES.

§ 350. We shall take the torpedo and the carp as examples of the two chief divisions of the class, as we did in speaking of the male organs.§

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* Caldesi, tab. 6, fig. 9, 10.

† Rösel, tab. 4, fig. 2, tab. 7, 8.

‡ Ibid. tab. 21, fig. 24.
The structure is the same in the *rana pipa* (Surinam toad). See Camper's *Kleinere Schriften*, vol. i. pt. 1, tab. 3, fig. 1.

§ Cavolini, *loco citato.*

In the former fish[*] there are two uteri, communicating with the cloaca by means of a common vagina. The oviducts form one infundibulum, which receives the ova as they successively arrive at maturity. These are very large in comparison with those of the bony fishes. The yolk, in its passage through the oviduct, acquires its albumen and shell. The latter is of a horny consistence, and is known by the name of the sea-mouse.[†] It has an elongated quadrangular figure, and its four corners are curved and pointed in the skate, while they form horny plaited eminences in the *sharks*.[‡] The secretion of the albumen, and the formation of the shell are performed by the papillous internal surface of the duct; and chiefly by two glandular swellings which appear towards its anterior extremity in the summer months while the eggs are being laid).[§]

The structure is much more simple in the *carp*, and probably also in the other oviparous bony fishes. The two roes occupy the same position as the soft roe of the male does. They are placed at the side of the intestines, liver, and swimming bladder, as far as the anus. They consist of a delicate membrane inclosing the ova, which are all of one size, and extremely numerous (more than 200,000 in the *carp*); and terminate by a common opening behind the anus.[||]

The ovaria of fishes generally contain a very large number of ova, so as to account to us satisfactorily for the astonishing multitudes in which some species are formed. In a perch, weighing one pound, two ounces, there were 69,216 ova in the ovarium; in a mackarel of one pound, three ounces, 129,200; in a carp of eighteen inches, Petit found 342,144; and in a sturgeon of one hundred and sixty pounds, there was the enormous number of 1,467,500.

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[*] Lorenzini, tab. 3, fig. 1, 2; also Monro's *Physiology of Fishes*, tab. 2 and 13 of the *skate*.

[†] W. G. Tilesius *über die so genannten Seemäuse oder hornartigen Fischeger.* Leipzig. 1802, 4to. tab. 4, 5.

[‡] J. Hermann, *Tabula Affinitatum Animalium*, p. 279.

[§] These temporary organs were known to Aristotle, who called them breasts. See also Rondelet *De Piscibus Marinis*, p. 380. Collins, vol. ii. tab. 43. Monro and Tilesius, *loc. citat.*

[||] Petit, *loc. citat.*

INSECTS.

§ 351. We shall here notice the two species only which were mentioned in the former chapter.*

Each of the large ovaria of the *gryllus verrucivorus* contains about fifty ova disposed in bundles. The two organs are connected together at their posterior extremities, and open between the two sheaths of a part by which they are discharged from the body.†

In the *silkworm moth,*‡ on the contrary, the ovarium resembles four rows of pearls; each row contains about sixty ova, which are laid from the end of the abdomen, after passing through a short duct, which has, however, connected with it several vesicular processes of uncertain use.

VERMES.

§ 352. We shall describe here the female genitals of those two animals only, whose male organs were noticed in the preceding chapter.§

The opening of the genitals of the *female round-worm* (*ascaris lumbricoides*) is situated near the middle of the body, and leads to a short canal, which divides into two tubes. These gradually contract into two slender, thread-like oviducts, which are very long and variously convoluted.|| It happens occasionally that the integuments of the *worm* burst, and some turns of the duct protrude: these have been mistaken for young worms, and have given rise to the erroneous notion that the animal is viviparous.

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* In the works quoted at page 331, delineations of the female organs of generation of the insects there mentioned will be found.

† Rösel, *loc. citat.* tab. 9, fig. 3.

‡ Malpighi, tab. 12, fig. 1, 2.

§ For an account of these parts in some other genera, see the works quoted in note 15, § 329.

|| Tyson, in the *Philos. Trans.* vol. xiii. fig. 2, or in his works. London, 4to. 1751.

(The same parts have also been represented by Dr. Hooper, in the *Memoirs of the London Medical Society*, vol. v.; and by Dr. Baillie, in his elegant *Fasciculi of Morbid Anatomy*, fascic. 4, pl. 9, fig. 3 and 5, T.)

The structure of the parts is very simple in the *cuttle-fish.* There are two ovaria, containing ova of various sizes, and a common tube leading to the anus.*

The genital tubes of the ascaris contain a milky fluid, which, when examined by the microscope, is found to contain numerous ova.

The *ascaris vernicularis* possesses a genital apparatus of the same appearance with that of the *lumbricoides.* Dr. Hooper in *Trans. of the Lond. Med. Soc.*

The ova of the cuttle-fish, when discharged from the body, are connected into bunches, exactly resembling grapes, by a tenacious and ductile substance. The similarity is so striking as to have given rise to the term of *sea-grapes*, which is applied to them in common language. In the *sepia octopus* and *loligo* (calmar) they form small masses.

Most of the gasteropodous mollusca are true hermaphrodites, and have the male and female organs of generation united in the same individual; but they copulate, so that each fecundates and is fecundated. The common slug (*limax*) and snail (*helix*) afford the most familiar examples of this structure. They possess an ovarium, oviduct, testis, vas deferens, and penis. The oviduct and vas deferens open into a cavity situated under the right superior horn; and the penis is contained in the same cavity. The latter part enters the oviduct of the other animal at the time of copulation.

The snail has, in addition to these organs, a very singular one, the use of which is quite obscure. It consists of a cavity with an eminence at bottom, from which a sharp pointed, thin, calcareous body proceeds. This can be thrust forth from the cavity, and is employed by the snails to prick each other before the act of copulation.

In the acephalous mollusca, such as the oyster, muscle, &c. there is no discernible organ of generation, except an ovarium, which varies in size and colour at different periods of gestation.

The same observation holds good also of the *asterias* (star-fish) and *echinus* (sea-urchin). In both these genera the ovaria consist of several distinct masses of ova.

The process of generation in the zoophytes resembles the growth of buds and branches in trees, and therefore these animals contain no generative organs, nor have any distinction of sex. This is the case in the polype (*hydra*) and the sea anemone, (*actinia*) where the young shoot out from any part of the surface of the parent. If these animals are cut in two, the divided portions will form perfect animals.

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* Turb. Needham, *Nouvelles Obs. Microsc.* tab. 2.

Compare with this the delineations by Lister, which indeed are somewhat different. *Conchylior. bivalv. exercit. Anat. Tertia.* Lond. 1696, 4to. tab. 1, fig. 10; and by Swammerdam, tab. 52, fig. 10.

CHAPTER XXV.

ON THE FŒTUS OF THE MAMMALIA, AND THE ORGANS WITH WHICH IT IS CONNECTED.*

§ 353. The first parts which can be discerned in the uterus after impregnation, are the membranes (*involucra*) of the ovum; in which (the marsupial animals excepted) the embryo itself becomes visible after a certain period. By means of the navel-string the fœtus is connected to these membranes, and consequently to the uterus of the mother; from which its nourishment is derived until the time of birth. It will, therefore, be the natural method to pass from the description of the uterus to that of the membranes, and other parts of the after-birth; and to consider in the last place whatever may be worthy of remark concerning the embryo itself.

§ 354. The mode of connexion of the pregnant uterus with the membranes of the ovum, and thereby with the embryo itself, displays three chief differences in the various mammalia.

Either the whole external surface of the ovum adheres to the cavity of the uterus; or the connexion is effected by means of a simple *placenta;* or by numerous small placentæ (*cotyledons*).

§ 355. The first kind of structure is observed in the *sow;*†

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* Much information on the subject of this and of the last chapter is contained in Dr. J. F. Lobstein's *Essais sur la Nutrition du Fœtus.* Strasb. 1802, 4to. See also some excellent observations on the cavities of the fœtus in the three first classes of red-blooded animals by Dutrochet, Cuvier, Breschet, Mondini, and Alessandrini, in Meckel's *Archiv.* vol. v. p. 535, and vol. vi. p. 385.

† Fab. Ab Aquapend. tab. 25 and 26. Daubenton, tom. v. tab. 21, 22.

and is still more manifest in the *mare*. In the latter case, the external membrane of the ovum, the chorion, may be said to form a bag-like placenta. Numerous and large branches of the umbilical vessels ramify through it, particularly in the latter half of the period of pregnancy; and its external surface is covered with innumerable flocculent papillæ, which connect it to the inside of the uterus.*

§ 356. In those animals of this class, where the embryo is nourished by means of a placenta, remarkable varieties occur in the several species; sometimes in the form and successive changes of the part, sometimes in the structure of the organ, as being more simple or complicated.

In most of the digitated mammalia, as well as in the quadrumana, the placenta has a roundish form;† yet it consists sometimes of two halves lying near together; and in the *dog*, *cat*, *martin*, &c. it resembles a belt (*cingulum* or *zona*).‡ Its form in the *pole-cat* is intermediate between these two structures; as there are two round masses joined by an intervening narrower portion.§

I have discovered a most remarkable instance of change in the form of this organ in the *hedgehog*. For some weeks after impregnation the placenta includes nearly the whole circumference of the chorion, and may be compared, in size and form, to a hazel-nut. It is spongy and vascular internally; but on the outer surface firm and tough, and approaching to cartilaginous hardness. It is not, however, of uniform strength throughout; but thinner and more flexible towards the concave side of the cornua uteri, than on the opposite part. (See

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* Fab. Ab Aquapend, tab. 21, 22; tab. 23, fig. 46.

† Daubenton, tom. vii. tab. 38, fig. 3, 4, of the *rat*.

Ibid. tab. 40, fig. 7, 8, of the *domestic mouse;* tom. viii. tab. 13, fig. 6, of the *mole*.

‡ It is represented in the *dog*, by Eustachius, tab. anatom. tab. 14, fig. 7, 8, by Fab. Ab Aquapend. tab. 27, 28; and by Daubenton, tom. v. tab. 50.

In the *cat*, by Needham, *De Formato Fœtu*, tab. 4. fig. 1; and Daubenton, tom. vi. tab. 6.

In the *martin*, ibid. tom. vii. tab. 20.

§ Ibid. tom. vii. tab. 27.

Plate VIII. fig. 1.) As pregnancy advances, this thinner portion increases, and gradually assumes a nearly membranous structure, while the opposite thick part forms a firm and dense placenta of a saddle-like shape with extenuated margins, (Plate VIII. fig. 2). This lies in the more mature fœtus nearly across the ilia; so that the neighbouring parts are protected from any injury which might have arisen from accidental pressure. For the final purpose of this singular, and, as far as I know, unique construction, is the preservation of the tender embryo in the abdomen of an animal, which rolls itself up with such force, that, without this provision, the pregnant uterus and its contents would be exposed to a most dangerous pressure.

In several species of digitated mammalia the external surface of the placenta is provided with a white and apparently glandular body (*corpus glandulosum* Everardi,* or *subplacenta,*) smaller than the proper placenta by which it is inclosed.† In proportion as the embryo becomes more mature, this part admits of more easy separation from the placenta.

§ 357. The placenta of the *bisulca* is divided into numerous *cotyledons;* the structure of which is very interesting, as it elucidates the whole physiology of this organ. The parts designated by this appellation are certain fleshy excrescences, (*glandulæ uterinæ*) produced from the surface of the impregnated uterus, and having a corresponding number of flocculent fasciculi of blood-vessels, (*carunculæ*) which grow from the external surface of the chorion implanted in them. Thus the *uterine* and *fœtal* portions of the placenta are manifestly distinct from each other, and are easily separable as the fœtus advances to maturity. The latter only are discharged with the after-birth, while the former, or the *cotyledons*, gradually disappear from the surface of the uterus after it has parted with its contents. The number and form of these excrescences vary in the different genera and species. In the *sheep* and *cow* they sometimes amount to a hundred. In the former animal and the *goat*, they are, as the name implies, concave eminences;* while on the contrary, in the *cow*, *deer*, &c. their surface is rounded or convex.†

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* *Cosmopolitæ Historia Naturalis*, 1686, 12, p. 60.

† In the *hare* it is represented by Daubenton, tom. vi. tab. 46.

In the *rabbit* by Needham, tab. 3; and De Graaf, tab. 26, 27.

In the *guinea-pig* by Fab. Ab Aquap. tab. 30; and Daubenton, tom. viii. tab. 4, fig. 6.

In the *water-rat*, ibid. tom. vii. tab. 46, fig. 4, 5.

§ 358. The trunks of the veins which pass from the placenta or carunculæ, and of the arteries which proceed towards these parts, are united in the *umbilical* chord, which is longer in the human embryo‡ than in any other animal. The navel, which continues visible during life in man, is not so apparent in other mammiferous animals.

In the *foal*, as in the child, the chord possesses a single umbilical vein;§ whilst most other quadrupeds have two, which unite however into a common trunk near the body of the fœtus, or just within it.||

§ 359. The amnion, or innermost of the two membranes of the ovum, which belongs to the pregnant woman, as well as to the mammalia, is distinguished in some of the latter, as for instance in the *cow* and *mare*, by its numerous blood-vessels; while on the contrary, in the human subject it possesses no discernible vascular ramification.

§ 360. Between the chorion and amnion there is a part found in most pregnant quadrupeds, and even in the *cetacea*, which does not belong to the human ovum, viz. the *allantois*, or *urinary membrane*. The latter name is derived from the connexion which this part has, by means of the *urachus*, with the urinary bladder of the fœtus; whence the watery fluid,

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* For a view of these parts in the *sheep*, see Fab. Ab Aquap. tab. 12, 14, 15.

† In the *cow*, Hoboken, particularly fig. 14 to 17.

In the *goat*, Daubenton, tom. vi. tab. 17.

‡ The *pole-cat* probably has the shortest chord. Daubenton, tom. vii. tab. 27, fig. 3.

§ Ruini, p. 189.

|| Hoboken, fig. 23, 27, in the *calf*.

which it contains, has been regarded as the urine of the animal. The term *allantois* has arisen from the sausage-like form which the part possesses in the *bisulca* and the *pig;*[*] although this shape is not found in several other genera and species. Thus, in the *hare, rabbit, guinea-pig,* &c. it resembles a small flask; and it is oval in the *pole-cat.* It covers the whole internal surface of the chorion in the *solidungula,* and therefore incloses the foal with its amnion. It contains most frequently in these animals, (although not rarely in the *cow*) larger or smaller masses of an apparently coagulated sediment in various forms and number, which has been long known by the singular name of the *horse-venom* or *hippomanes.*[†]

Some orders and genera of mammalia resemble the human subject in having no allantois; as the *quadrumana* and the *hedgehog:* nay, in the latter animal, the urinary bladder has no trace whatever of urachus; which even exists in a certain degree in the human subject; but its fundus is perfectly spherical in the fœtus. (See PLATE VIII. fig. 2, f.)

§ 361. There is in the *hedgehog,* as well as in the *dog, cat,* and others, a peculiar part called the *tunica erythroides,* (see PLATE VIII. fig. 1, c; fig 2, c) situated between the chorion and amnion like the allantois, for which it might easily be mistaken on the first view. It contains a watery fluid at the commencement of pregnancy, but is easily distinguished from an allantois, as it is not joined to the fundus of the bladder by the urachus, but is connected by means of the *omphalomesenteric veins,* (Plate VIII. fig. 2, k) with the mesenteric blood-vessels of the fœtus.[‡] This connexion constitutes a resem-

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[*] Fab. ab Aquap. tab. 13, fig. 29; and tab. 17, fig. 37, in the *sheep.* J. C. Kuhlemann has represented this part in an embryo of the nineteenth day after conception. *Observ. circa Negotium Generationis in Ovibus.* Götting. 1753, 4to. tab. 2, fig. 1, 2.

Hoboken, fig. 10 to 13 and 15, in the *cow.* Fabric. tab. 25, in the *pig.*

[†] Daubenton, tom. iv. tab. 9, fig. 1, 2, of the *horse.*

Hoboken, fig. 19, 21, and fig. 37, of the *cow.*

[‡] Fab. Ab Aquap. tab. 1, of the *dog.*

Needham, tab. 4, fig. 1, of the *cat.*

Wetter,

blance on one hand to the yolk-bag of the incubated bird, and on the other hand to that remarkable *vesicula umbilicalis*, which is observable in the early months of pregnancy.* The *tunica erythroides*, as well as that vesicula, are most complete in young embryos, and are, on the contrary, so diminished in subsequent periods, that their functions must be connected with the earlier stages of existence.†

It is nearly forty years since I first showed the analogy between the *tunica erythroides* and the *vesicula umbilicalis* of the human fœtus, in the first months after impregnation, as well as the natural state of the vesiculum umbilicale.‡

The *tunica erythroides* was first noticed by Everard as existing in animals, in his work entitled, *Novus et genuinus hominis brutique animalis exortus*. Melib. 1661; and there is an engraving of it in Needham's *Observationes Anatomiæ*, Leyd. 1743, under the name of *corpus glandulosum Everardi quod fœtum utero connectit*. Dr. Pochels of Brunswick has lately endeavoured to prove its existence in the human fœtus. See the *Edinburgh Medical and Surgical Journal*, vol. xxv. No. 87; and *The Lancet*, vol. x. p. 456.

§ 362. The first trace of the formation of an embryo cannot be discovered in the different species of this class until a considerable time after conception. The original formation, as in the human subject, is widely distant from the subsequent perfection of the mature fœtus:§ and the growth and formation

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Wetter, tab. 4, of the *hedgehog*. See also Drondi, *Supplementa ad Anatomiam et Physiologiam potissimum comparatam*. Leip. 1806, p. 15.

* *Comment. Soc. Reg. Scient.* Götting. vol. ix. p. 128, fig. 1.

† See Oken's and Kieser's *Beyträge zur vergleichenden Zoologie—Anatomie und Physiologie*, pt. 1 and 2, 1806 and 1807.

Meckel's *Beyträge zur vergleichenden Anatomie*, pt. 1, 1808; and *Archiv. für die Physiologie*, vol. ix. pt. 3, 1809.

Oken's *Isis*, 1818, p. 59.

‡ See Dr. Elliotson's excellent translation of the *Institutiones Physiologicæ, et Specim. Physiolog. comparatæ inter Animantia calidi sanguinis Vivipara et Ovipara*, 1788, in the ninth vol. of the *Commentat. Regalis Scient. Gotting.*

§ See delineations of the embryo of different animals in the early periods, viz. of the *rabbit* in De Graaf, tab. 26, fig. 8, 10; and in Haller, *Oper. Minor.* tom. iii. tab. 21, fig. 1-4. Of the *sheep* in Kuhlemann, tab. 2.

of the members, instead of proceeding alike in the whole class, are so ordered in particular species, that those external organs, which are most necessary to the young animal, according to its peculiar mode of life, are formed and completed the soonest. Hence arises the great size of the posterior hands of the fœtal *quadrumana*, of the feet of the *squirrel*, of such animals in short as are destined to live in trees; likewise of those of the *foal* and *kid*, which are obliged to use their legs immediately after birth, when compared with the corresponding parts of the mature human fœtus.

In the fœtal kangaroo, in that state at least in which it is first found in the false belly, the fore feet are much larger and stronger than the posterior ones, on account of the use to which the animal puts them in holding by the nipple. When the animal in a more mature state is in a manner born a second time, and must soon be left to itself, the posterior limbs increase to their well known enormous magnitude.

The erroneous observation concerning the supposed unshapeliness of the fœtus of the bear, which has been so often made since the time of Aristotle, would not require an express refutation in the present day, had it not been repeated by some modern zoologists, whose accuracy in general is much to be relied on. I have completely shewn how unfounded this supposition is, by the representation of a young bear's fœtus in another place,[*] and it appears to be very completely formed.

§ 363. The most important points, in which the fœtus of the mammalia differs from that of the human subject, have been already noticed. In other respects their structure seems to correspond;[†] at least, for instance, in the membrana pupillaris,[‡] in the thymus, thyroid, and suprarenal glands. Some

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[*] *Abbildungen Naturhistor. Gegenstände*, pt. 4, tab. 32.

[†] There is a view of the viscera of a fœtal *horse* in Ruini, p. 189, and in Daubenton, tom. iv. tab. 7.

Of the *sheep* in Kuhlemann, tab. 2, fig. 8.

Of the *calf* by Hoboken, fig. 24, 25.

[‡] Wrisberg, in the *Nov. Comment. Soc. Reg. Scient.* Goetting, tom. ii. p. 207.

Vide

trivial points of distinction are not noticed; such as the meconium resembling hard scybala in the bisulca, and animals of the mouse kind,* &c.

Vide S. C. Lucæ *Anatomische Untersuchungen der Thymus in Menschen und Thieren.* Frankf. 1811.

J. F. Meckel's *Abhandlungen aus der menschlichen und vergleichenden Anatomie.* Halle, 1806.

[*] Fleming's *Deutsche Jäger,* p. 130; and Harvey *De Generat. Animal.* p. 197.

CHAPTER XXVI.

ON THE BREASTS AND TEATS OF THE MAMMALIA.

§ 364. The nourishment of the young animal immediately after birth, is derived in this class from the milk of the mother, which is secreted in the *breasts.* This secretion, which is peculiar to the class in question, has given rise to the name *mammalia,* by which Linnæus has distinguished them. Teats have been even discovered in the ornithorhynchus;[*] but they seem also to be wanting in the males of some other species, as the hamster, and *lemur mongoz*; although this sex possesses them in general as well as the female. They are sometimes however found in smaller number in the former sex, as in the *dog,* or in a different situation, as in the *horse.*[†]

Numerous instances have occurred, in which milk has been secreted in the breasts of male animals, as in the *goat, ox, dog, cat,* and *hare,* as well as in men. I have treated more particularly of this physiological phenomenon in describing a *he-goat,*[‡] which it was necessary to milk every other day for the space of a year.[§]

Milk is commonly found in the breasts of newly-born children of both sexes; and the same observation holds good in the foal and calf.

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[*] Home, in the *Philos. Trans.* 1802, p. 69.

[†] Daubenton, in Fourcroy's *Médecine Eclairée,* tom. ii. p. 274.

"Naturalists were long at a loss to discover the mammæ and teats of this animal; in the male they were at length detected by Buffon, on the sheath of the penis. Mr. J. Hunter also made the same remark, without knowing that Buffon had previously noticed it; these teats are largest in the fœtus and young foal." Rees's *Cyclop.* art. *Anatomy of the Horse.*

[‡] The milking of he-goats, therefore, is not so extravagant a supposition as it appeared to the shepherd in Virgil,

> Qui Bavium non odit, amet tua carmina, Mævi;
> Atque idem jungat vulpes, et mulgeat hircos.

[§] *Hannöverschen Magazin,* 1787, p. 753.

Meckel gives the following account of his discovery of the mammæ in the ornithorhynchus, in his *Ornithorhynchi paradoxi descriptio anatomica*, published at Leipsic in the year 1826. This elaborate monograph contains the results of a minute dissection of a male and female ornithorhynchus, for which the author was indebted to the kindness of Mr. Green, the distinguished Professor of Anatomy to the Royal Academy.

It is well known to have been a common opinion, that the ornithorhynchus and ornithorhynchus hystrix were destitute of mammæ, and that upon this opinion was founded the argument for rejecting those animals from the class of mammalia. Cuvier, one of the latest writers on this subject, expressly states that they have no mammæ; and after a careful examination of the male ornithorhynchus, I was myself unable to detect any trace, either of papillæ or glands. With respect to the female, after having opened the abdomen, and removed the greater part of the viscera, I was prevented by various occupations from continuing my investigation of this subject, till the close of the year 1823, when on the 25th day of December, a day of good omen, I detected on the right side of the abdominal muscles, a small round mass, which at first bore the appearance of a portion of intestine accidentally pushed into this situation, but upon carefully examining the left side, I discovered a corresponding substance. The evening was too far advanced to permit me to pursue my investigation, but on the next morning, after a night rendered sleepless by anxious expectation, I returned to my work, and found that this substance was beyond all question a glandular structure. I was equally satisfied that this gland was a true mamma, an opinion which was more forcibly impressed upon my mind from its structure and situation, from its marked development in the female, and the want of it in the male, or at least its existence in so minute a degree as to have hitherto eluded the closest examination.

The following is an account of the situation, size, and structure of this gland. It is placed on the side of the abdomen, between the fleshy portion to which it adheres very loosely, the obliquus descendens abdominis and the anterior muscles of the femur, reaching at its upper extremity the external margin of the pectoralis major, and the lower extremity of the sternum. The marked development of this part renders it as surprising that it should hitherto have escaped notice, especially as so many ornithorhynchi, and among these so many females, have been dissected. The length of this gland was four inches, three lines; its breadth, about one inch, three or four lines; its greatest thickness four lines: its external shape is very oblong, as indeed is evident from these dimensions; its breadth is nearly uniform, but is a little narrower towards the lower extremity. There are exceedingly minute excretory ducts in the middle of the gland, which open externally. Although I could pass neither silk nor mercury through the ducts, which were of themselves, as I have observed, exceedingly narrow, and further contracted by the spirit of wine, and filled with a thick fluid, the area was nevertheless indicated in the skin. Although this part was covered with hair, there appeared nevertheless, upon removing them, an opening of about five lines in length, and three in breadth, surrounded with about eighty minute foramina, from which the hairs proceeded, and which were probably the orifices of the excretory ducts. There was, moreover, in the centre of this opening, a small depression of about two lines in diameter, destitute of hair, but having several unequal rugæ, among which one not equalling the size of a millet-seed, was more conspicuous than the rest. These were undoubtedly papillæ, and orifices of the ducts.

This discovery confirms the opinions of Oken and de Blainville, who although they had never examined a female ornithorhynchus, nevertheless asserted that there could be no doubt of the existence of mammæ, on account of the numerous analogies presented by that animal with the other mammalia. This discovery also refutes the arguments of those who inferred a want of mammæ from the absence of nipples, from the shape of the bill, which is by no means adapted for sucking, and from ova said to have been found in the ovaries, and in nests, though there could be no foundation for this last assertion.

§ 365. The position and number of the teats varies considerably in the different species. Several irregularities occur in the latter point, particularly among the domestic animals.* Numerous exceptions must be made in some species, as the *domestic sow*, the *guinea-pig*, and others, to the general rule, which assigns to animals twice as many teats as the number of young which they ordinarily produce.

Their situation is the most singular in the female marsupial animals, where there existence can scarcely be recognized, except at the time when the young are actually contained in the abdominal pouch, or false belly.

Tyson, who on all other occasions displays the greatest acuteness, could discover no trace of teats in his female opossum. D'Aboville expressly asserts, that they are formed by the suction of the young, that their number, therefore, in animals which are giving suck, exactly corresponds to the number of young at that period; and that they are placed without any symmetry, being formed wherever the young animals may happen to attach themselves on their arrival in the abdominal pouch.*

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* Buffon, tom. x. p. 295.

In an opossum which I possessed for several years, and whose ovaria discovered no trace of any previous impregnation, there were three pairs of teats in the false belly, very small indeed, and flat, but regularly arranged in a half-moon.

A species of toad (the *rana pipa*, or Surinam *toad*) has a structure somewhat analogous to the false belly of the marsupial mammalia. There are several cells, amounting in number to seventy or eighty, formed by the integuments of the back of the female. The ova are placed in these, and go through their different changes to the formation of the young *frog*. The integuments which form these cells, appear to have no peculiarity in their organization; nor are the cells formed until the time at which they are to receive the ova.

§ 366. In the singular animals which have been just alluded to, as well as in those which live in the water, or under ground, the mammary glands, for reasons which must be very obvious, lie flat under the skin, and do not project so as to form breasts or udders; neither do the lactiferous ducts possess such dilatations and cavities as are observed in the bisulca, the mare, and others.† In those animals which have their breasts placed on the chest, (*mammæ pectorales*) these organs never possess that form which so peculiarly distinguishes the human female in the bloom of life.

The mammæ of animals are not surrounded with that quantity of fat which is observed in the human female, hence they are not very apparent except at the period of suckling, when they become distended with milk.

Another remarkable difference occurs in the structure of the nipple. This part in women has about fifteen openings, which are the terminations of as many lactiferous tubes. In the other mammalia it is hollow, and has only one or two orifices. Its cavity communicates with two large reservoirs, in which the lactiferous tubes terminate.

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* See *Voyages du Marq. De Chastellux dans l'Amerique Septentrionale,* tom. ii. p. 332.

† Daubenton, tom. v. tab. 12, of a *goat* which had double teats on each udder. See also Steinmüller's *Beschreibung der schweizerischen Alpenwirthschaft,* vol. ii. p. 150.

CHAPTER XXVII.

ON THE INCUBATED EGG.

§ 367. The various vital processes of nutrition and formation, which are carried on in the fœtus of the mammalia, while in its mother's body, and by means of the most intimate connexion with the parent, are effected in the incubated chick by its own powers, quite independently of the mother, and without any extraneous assistance, except that of the atmospheric air, and a certain degree of warmth.

§ 368. The egg is covered, within the shell, by a white and firm membrane, (*membrana albuminis*) which contains no blood-vessels. The two layers of this membrane, which in other parts adhere closely to each other, leave at the large end a space which is filled with atmospheric air.*

This membrane includes the two *whites of the egg*, each of which is surrounded by a delicate membrane. The external of these is the most fluid and transparent, the inner one thicker and more opaque; they may be separated in eggs which are boiled hard.

The internal white surrounds the yolk, which is contained in a peculiar membrane called the *yolk-bag*. From each end of this proceeds a white knotty body, which terminates in a flocculent extremity in the albumen. These are called the

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* J. C. Hehl, *Observata Physiologica de Natura et Usu Aeris, Ovis Avium inclusi.* Tubing. 1796, 4to.

See Dr. Paris's admirable paper on this subject, in the *Transactions of the Linnæan Society*, vol. x. p. 2, 304.

chalazæ, or *grandines.* Leveille distinguishes a third *white,* and considers the chalazæ as absorbing vessels floating in it, and destined to absorb it as well as the inner albumen, and mix them with the yolk during incubation.*

A small, round, milk-white spot, called the tread of the cock, (*cicatricula* or *macula*) is formed on the surface of the yolk-bag. It is surrounded by one, or more, whitish concentric circles, (*halones* or *circuli*) the use of which, as well as that of the cicatricula itself, and of the chalazæ, is not yet ascertained.

§ 369. We now proceed to notice the wonderful successive changes which go on during the incubation of the egg; and the metamorphoses which are observed both in the general form of the chick, and in particular viscera. The periods of these changes will be set down from the hen, as affording the most familiar example.† It will be best to give, first, a cursory chronological‡ view of the whole process, and then to make a few remarks on some of the most important parts of the subject.

§ 370. A small shining spot of an elongated form, with rounded extremities, but narrowest in the middle, is perceived at the end of the first day, not in nor upon the cicatricula, but very near that part on the yolk-bag, (*nidus pulli, colliquamentum, areola pellucida*). This may be said to appear before-hand, as the abode of the chick which is to follow.

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* *Sur la Nutrition des Fœtus.* Par. 1799, 8vo.

† The following works may be referred to for representations of the formation of the chicken in the egg.

Malpighi, *De Formatione Pulli.* Lond. 1673, 4to.; also *De Ovo Incubato,* 1686, fol.

W. Langly, in Schrader, *Observ. et Histor. de Generatione.* Amst. 1674, 12mo.

Ant. Maitre-Jan, *Observat. sur la Formation du Poulet.* Par. 1722, 12mo.

C. F. Wolff. *Theoria Generationis.* Hal. 1759, 4to. tab. 2; also in the *Nov. Comment. Acad. Petropolitan.* tom. xii. xiii. and xiv.

Meckel, *Beyträge zur vergleichenden Anatomie,* vol. i. pt. 1, p. 83.

And Sir E. Home's *Lectures on comparative Anatomy.*

As the plates of Langly and Wolff represent only the earlier periods, and the others are not executed with that elegance and clearness which they ought to possess; I have given in the fourth and seventh parts of my *Abbildungen der Naturhistorich-Gegenstände,* some neat and accurate representations, taken from two periods, in which the most important phenomena of incubation are most clearly discernible.

‡ The periods of the different changes are set down as I have ascertained them in my own repeated observations.

No trace of the latter can be discerned before the beginning of the second day, and then it has an incurvated form, resembling a gelatinous filament, with large extremities, very closely surrounded by the amnion, which, at first, can scarcely be distinguished from it.

About this time the halones enlarge their circles, but they soon after disappear entirely, as well as the cicatricula.

§ 371. The first appearance of red blood is discerned on the surface of the yolk-bag, towards the end of the second day. A series of points is observed, which form grooves, and these, closing, constitute vessels, the trunks of which become connected to the chick. The vascular surface itself is called *figura venosa*, or *area vasculosa:* and the vessel by which its margin is defined, *vena terminalis*. The trunk of all the veins joins the vena portæ, while the arteries, which ramify on the yolk-bag, arise from the mesenteric artery of the chick.

§ 372. On the commencement of the third day, the newly-formed heart (the primary organ of the circulating process, which now commences) is discerned by means of its triple pulsation, and constitutes a threefold *punctum saliens*. Some parts of the incubated chicken are destined to undergo successive alterations in their form; and this holds good of the heart in particular. In its first formation it resembles a tortuous canal, and consists of three dilatations lying close together, and arranged in a triangle. One of these, which is properly the right, is then the common auricle; the other is the only ventricle, but afterwards the left; and the third is the dilated part of the aorta (*bulbus aortæ*).

About the same time, the spine, which was originally extended in a straight line, becomes incurvated; and the distinction of the vertebræ is very plain. The eyes may be distinguished by their black pigment, and comparatively immense size; and they are afterwards remarkable in consequence of a peculiar slit in the lower part of the iris.*

I have found an exactly similar slit in the iris of the common lizard, (*lacerta agilis*) before it had attained maturity. Thus this structure belongs to such animals as have no *membrana pupillaris.*

§ 373. From the fourth day, when the chicken has attained the length of four lines, and its most important abdominal viscera, as the stomach, intestines, and liver, are visible, (the gall bladder, however, does not appear till the sixth day,) a vascular membrane (*chorion,* or *membrana umbilicalis*) begins to form about the navel; and increases in the following days with such rapidity, that it covers nearly the whole inner surface of the shell within the membrana albuminis during the latter half of incubation. This seems to supply the place of the lungs, and to carry on the respiratory process instead of those organs. The lungs themselves begin indeed to be formed on the fifth day; but, as in the fœtus of the mammalia, they must be quite incapable of performing their functions while the chick is contained in the amnion.

§ 374. Voluntary motion is first observed on the sixth day, when the chick is about seven lines in length.

Ossification commences on the ninth day, when the ossific juice is first secreted, and hardened into bony points (*puncta ossificationis*). These form the rudiments of the bony ring of the sclerotica, which resembles at that time a circular row of the most delicate pearls. I have found this part much more elegantly formed than in the hen, in the incubated pea-fowl of the fourteenth and following days.

At the same period, the marks of the elegant yellow vessels (*vasa vitelli lutea*) on the yolk-bag, begin to be visible.

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* Malpighi, *De Format. Pulli,* tab. 2, fig. 18, 21; and *De Ovo,* tab. 3, fig, 18, 20; tab. 4, fig. 21.

Abbildungen, n. G. pt. 7, tab. 64.

See also Haller *Sur la Formation du Cœur dans le Poulet,* tom. i. pp. 193, 194; tom. ii. p. 160.

On the fourteenth day the feathers appear; and the animal is now able to open its mouth for air, if taken out of the egg.

On the nineteenth day it is able to utter sounds; and on the twenty-first to break through its prison, and commence a second life.

§ 375. We shall conclude with one or two remarks on those very singular membranes, the yolk-bag and chorion, which are so essential to the life and preservation of the animal.

The chorion, that most simple yet most perfect temporary substitute for the lungs, if examined in the latter half of incubation in an egg very cautiously opened, presents, without any artificial injection, one of the most splendid spectacles that occurs in the whole organic creation. It exhibits a surface covered with numberless ramifications of arterial and venous vessels. The latter are of the bright scarlet colour, as they carry oxygenated blood to the chick; the arteries, on the contrary, are of the deep or livid red, and bring the carbonated blood from the body of the animal. Hence, as is well known, the incubated bird perishes if the shell be varnished over, as the respiratory process is thereby suspended. The trunks of the arteries are connected with the iliac vessels; and on account of the thinness of their coats, they afford the best microscopical object for demonstrating the circulation in a warm-blooded animal.

§ 376. The other membrane, the *membrana vitelli*, is also connected to the body of the chick; but by a two-fold union, and in a very different manner from the former. It is joined to the small intestine, by means of the *ductus vitello-intestinalis*, (*pedunculus, apophysis*) and also by the blood-vessels, which have been already mentioned, (§ 368) with the mesenteric artery and vena portæ. This is regarded by Leveille merely as a ligament. It is well known that no true yolk is discoverable in the intestine of the incubated chick. Yet sometimes (not indeed always, but under certain circumstances not yet sufficiently understood) air will pass from the intestine through this part into the yolk-bag. This fact, which was noticed by Haller, and after him by Maitrejan, has occurred also to myself in the case of a duck of the twenty-second day.

The analogous umbilical bag of the fœtal-shark, (which is found also in several other fishes, and some reptiles) is connected to the small intestine; at least to the *bursa entiana,* which is a peculiar dilatation of the posterior end of the intestine.*

In the course of the incubation the yolk becomes constantly thinner and paler by the admixture of the inner white. At the same time innumerable fringe-like vessels with flocculent extremities, of a most singular and unexampled structure, form on the inner surface of the yolk-bag, opposite to the yellow ramified marks above-mentioned, and hang into the yolk.* There can be no doubt that they have the office of absorbing the yolk, and conveying it into the veins of the yolk-bag;† where it is assimilated to the blood, and applied to the nutrition of the chick. Thus, in the chicken, which has just quitted the egg, there is only a remainder of the yolk and its bag to be discovered in the abdomen. These are completely removed in the following weeks, so that the only remaining trace is a kind of cicatrix on the surface of the intestine.

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* Collins, vol. ii. tab. 33, fig. 2; and Charleton *De Differentiis Animalium,* p. 84. Augs. 1677.

† In numerous and varied microscopical examinations of the yolk-bag in the latter weeks of incubation, I think I have observed the actual passage of the yolk from the yellow flocculent vessels of the inner surface of the bag into the blood-vessels, which go to the chicken: that is, I have seen manifest yellow streaks in the red blood contained in those veins.

EXPLANATION OF THE PLATES.*

Excepting in Plate II. *and fig.* 2 *of Plate* VIII. *the objects are represented of the natural size.*

PLATE I.

The Skull of the *duck-billed animal* (*ornithorhynchus paradoxus*). A piece of the right side of the cranium has been broken off to shew the interior. The skull is devoid of sutures.

a, b. The two occipital condyles.
c. The peculiar bony falx.
d. The os malare.
e. The right orbit.
f. The broad processus mandibularis of the upper jaw.
g. A similar process on the lower jaw.
h. The condyloid process of the jaw.
i. The serrated edge of the fore and lateral part of the jaw, as in the duck.
k. The second branch of the fifth pair of nerves.
l, m, p. Twigs of this branch distributed to the integuments covering the bill.
n, o. The intermaxillary bone of this side.

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* These Plates were not given in the original edition.

PLATE II.

The Pelvis and Ossa Femorum of the *ostrich* (*struthio camelus*).

a, b. The os sacrum, (twenty inches long).
c, d, e. The ossa innominata, united anteriorly.
f, g. The ossa femorum, entirely devoid of medullary substance.

PLATE III.

The right articulated Wing of the *Cape penguin* (*aplenodytes demersa*).

The wing-bones are particularly distinguished by their very flat and compressed form, by two additional bones on the elbow, as well as by the want of the bone of the thumb.

1. The lower ends of the bone of the upper arm.
2, 3. The two additional bones.
4. The ulna.
5. The radius.
6, 7. The two bones in the carpus.
8. The divided os metacarpi.
9, 10. The two phalanges of the forefinger.
11. The adjoining finger consisting only of one phalanx.

PLATE IV.

The Skull of a *duck*, more particularly for the purposes of comparison with the same part in the *ornithorhynchus*, (Pl. I.).

a. The single occipital condyle.
b. The os quadratum.
c. The ossa lachrymalia.

d. The elastic laminæ of bone for the moveable connexion of the upper jaw with the cranium.

e. The membranous conchæ of the nares.

f, i. The first branch of the fifth pair.

g. Twigs of this nerve to the integuments covering the upper mandible.

h, i. The second branch of the fifth pair.

k, l, m. Distribution of this branch to the upper mandible.

h, n. The third branch of the fifth pair.

o. A twig to the integuments of the lower mandible.

PLATE V.

A vertical Section of the Skull and Upper Mandible of a *young toucan* (*tucanus ramphastos*).

a. The cavity of the cranium.

b. The membranous conchæ of the nares.

c. A large fossa in the bill before these conchæ.

d. A membranous vertical septum by which this fossa is divided.

e, f. The horny upper mandible, the internal structure of which is cellular.

PLATE VI.

The Eye of a *Greenland seal* (*phoca groënlandica*).

a. The very thin cornea.

b. The thick anterior zone of the sclerotica.

c. The thin, yielding middle zone and its diameter.

d. The posterior part of the sclerotica, very thick, and almost of a cartilaginous structure.

e. The broad *ciliaris orbicularis.*

f. The iris.

g. The pupil.
h. The anterior surface of the crystalline lens.
i. The optic nerve.

PLATE VII.

The Female Organs of Generation in the *opossum* (*didelphis marsupialis*) with the neighbouring viscera. The vagina is laid open from the side.

a, b. The part common to both vaginæ.
c. The double clitoris, with the glans projecting from the foreskin.
d. The opening of the urethra.
e. The vagina of the left side, unopened.
f. The vagina leading to the right side, with the part common to both longitudinally divided and kept apart from each other.
g. The large lateral convolution on the right side of the uterus.
h. This, together with the one of the opposite side, o, opening into a common cavity.
i, k. The cornua uteri.
l. The fine and tortuous convolutions of the right Fallopian tube.
m. The ovarium.
n, o, p, q, r, s. The same parts on the left side.
t. The empty bladder.
u, u. The end of the large intestines.
v. The anus.
w, x. The scent bags.
y, z. The openings of their excretory ducts.

PLATE VIII.

Embryos of *hedgehogs* at different periods, to show the changes which occur in the placenta.

Fig. 1.

A very young Embryo.

a, b, b. The oval *chorion* opened; the anterior half having been removed.

a. Its thick, and nearly cartilaginous portion.

b, b. The thinner lubricated parts.

c. The *tunica erythroides.*

d. The embryo, with its *amnion,* which had hitherto been inclosed in the *chorion.*

Fig. 2.

An Embryo in a more mature state.

a, b. The saddle-shaped placenta.

c. The tunica erythroides.

d. The abdomen of the embryo opened; its intestines and vessels are represented in fig. 1.

e. The liver.

f. The bladder without urachus.

g, h. The two umbilical arteries.

i. The umbilical vein.

k. The omphalomeseraic vessels.

THE END.

J. M'Creery, Tooks Court,
Chancery-lane, London.

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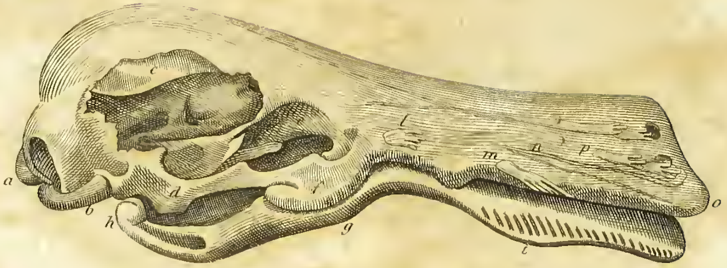
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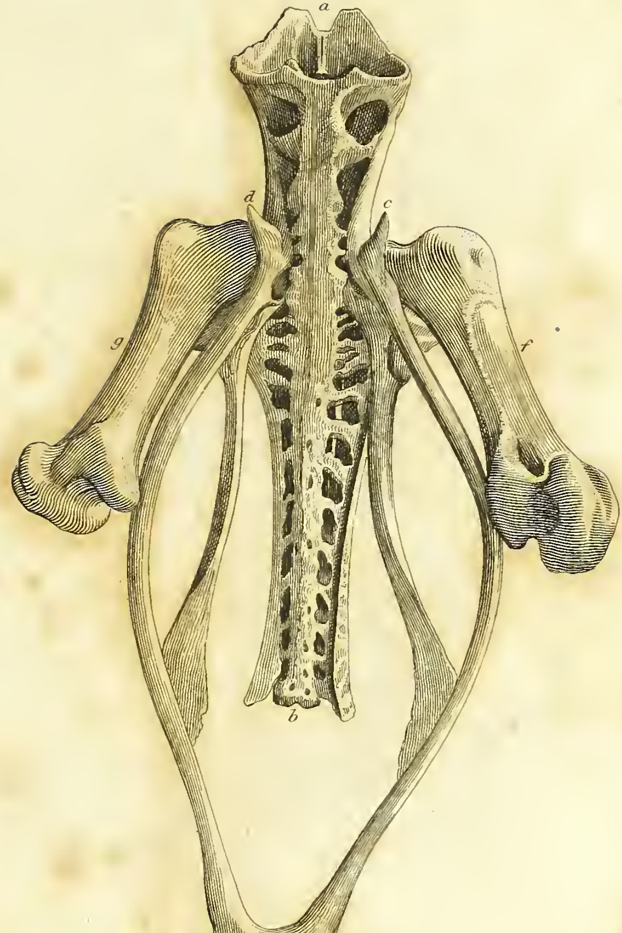
No. II.



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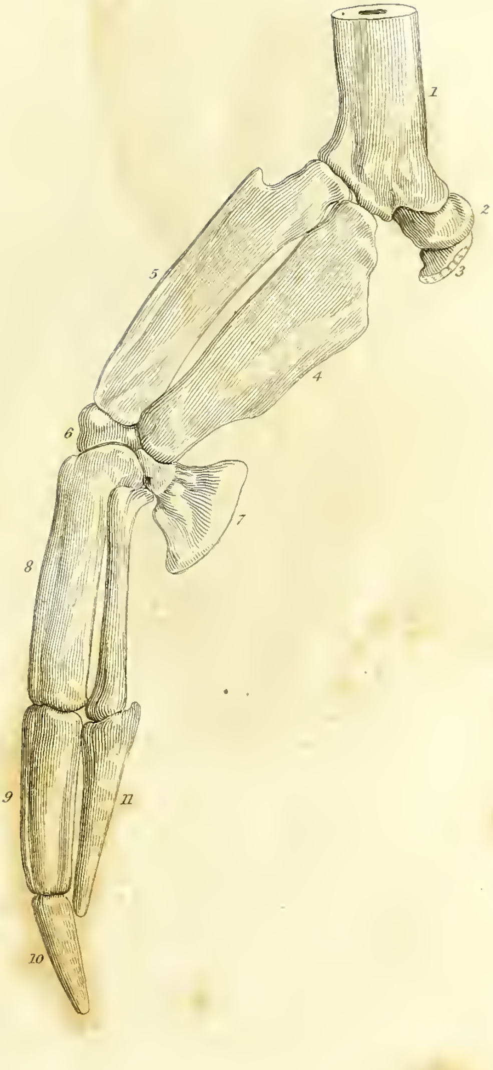
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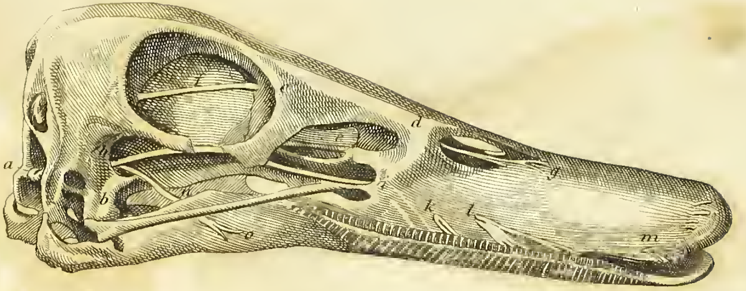
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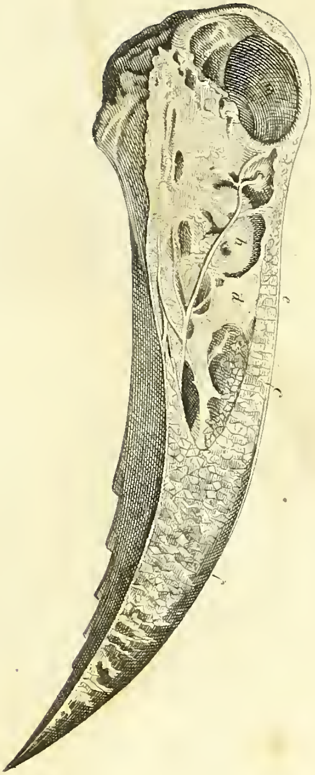

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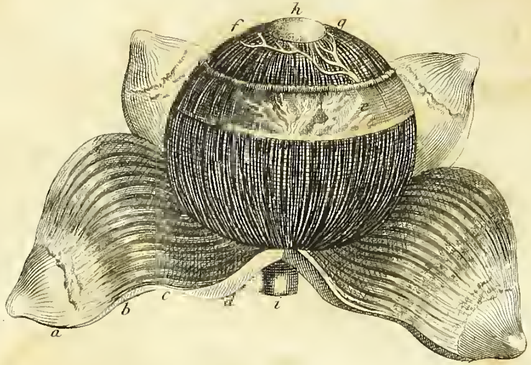
No. VI.



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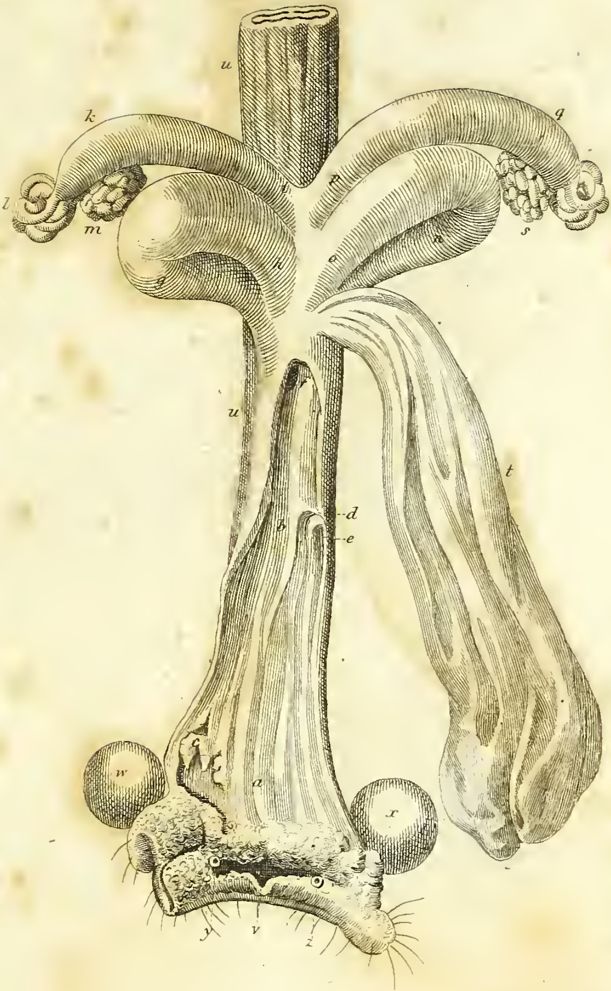
Nº VII.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N°. VIII.

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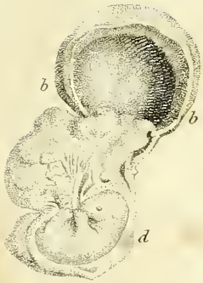

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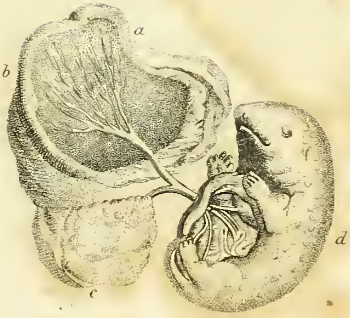

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